THE UNIVERSITY OF ALBERTA

THE INFERENCE ABILITIES OF ELEMENTARY SCHOOL STUDENTS

BY

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR

THE DEGREE OF MASTER OF EDUCATION

DEPARTMENT OF ELEMENTARY EDUCATION

EDMONTON, ALBERTA

FALL, 1972

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled, "The Inference Abilities of Elementary School Students", submitted by Maxwell Perry Mark Plester, in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

The main purpose of this study was to discover the present average inference ability levels of elementary school students with respect to two inference tasks: a) visual and b) auditory-haptic.

The experimental sample for the visual task consisted of one hundred and eight children, eighteen students being drawn from each of the grades one through six. Sixty-four students drawn from the same sample were used for the auditory-haptic task. Each student was assigned to a high, average or low intelligence group within each grade level on the basis of an I.Q. test administered during the course of the study.

During the visual inference testing sessions, each student was presented with patterns of blocks and/or slopes hidden in an 'inference machine'. The student was asked to infer the nature and distribution of the hidden objects on the basis of the final distribution of steel balls placed in slots in the 'machine'.

The auditory-haptic inference task consisted of the presentation to the student of six identical aluminum boxes each containing a different object with distinctive physical characteristics. Each child was asked to infer as much as possible about the nature of each object from observations involving manipulation of each closed box.

Complete audio-taped and written records were kept of the children's responses to the tasks.

Analyses of the resulting data indicated the following:

1. A significant relationship exists between visual inference score and auditory-haptic inference score as well as between each inference score and age, general intelligence, spatial relations ability and numerical ability.

2. Essentially, no significant difference exists between boys and girls in inference ability.

3. With respect to intelligence, the high I.Q. groups generally performed significantly better on the visual inference task than did the low I.Q. group. No significant differences were found to exist between any paired I.Q. groups on the basis of performance with respect to the auditory-haptic inference task.

4. Significant differences in visual inference ability were found to occur between grade levels, a rapid growth in these abilities occurring between grades one and two and grades two and three, a gradual growth taking place thereafter.

5. Scores obtained for the auditory-haptic inference task appeared to indicate that grades one, two and three preferred to use different criteria in characterizing the properties of objects than did grades four, five and six.

An important implication of this study was that experience designed to improve inference abilities among children should be fostered, since a continual increase in inference ability from grade one through six was observed.

ACKNOWLEDGEMENTS

The writer welcomes the opportunity to express his sincere gratitude to the many people who helped to make this thesis a reality.

Special thanks are due Dr. D.W.R. Wilson, chairman of the thesis committee, for his advice and constructive criticism throughout the past year.

Thanks are also extended to Dr. L. D. Nelson, Dr. T. O. Maguire and Dr. M. Horowitz for their interest in, and acceptance of this project.

The writer wishes to extend his appreciation to Dr. W. G. Cathcart for his able assistance with the statistical analysis and research design.

Recognition is given to the administrators, teachers, and students of the Edmonton Public, Edmonton Separate, and County of Strathcona school systems, without whose co-operation this study would have been impossible.

Special appreciation is given to the writer's family, especially his wife Margaret, for their everpresent support, encouragement and patience.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

The past decade has seen an evolutionary shift in science education from emphasis upon information for its own sake to concern for process, inquiry and problem solving. This change is reflected in the Alberta Science Curriculum by the inclusion of the following statement in the discussion of the objectives of science:

> The new elementary school science program has two fundamental but inseparable objectives. By emphasizing the development and use of inquiry skills as tools of investigation, the program is designed to enable the student to become an active and dynamic investigator of science. To have the student develop basic science concepts is a second aim. . . . (Curriculum Guide, p. 5) The intent is that the teacher will develop a balanced program where process and content receive equal emphasis (Curriculum Guide, p. 7).

THE PROBLEM

The importance which has been attached to the attainment of these objectives necessarily means that science curriculum development and student evaluation must also be carried out in terms of the stated objectives.

The objectives which have been stressed in the past have been those centered around concepts. Evaluation has been by means of paper and pencil tests almost exclusively, and calling largely for recall of memorized information.

Obtaining suitable methods for measuring student performance in handling process skills is most difficult. Few tests purporting to measure process skills are available and as Victor (1967) states, up

to the present too much stress in assessing the effectiveness of new programs has been placed upon teacher comment and evaluation of a purely testimonial and subjective nature. It is now imperative that new, objective measurement and evaluation procedures be formulated in order to properly carry out the assessment of intrinsic student abilities and of the effectiveness of implementation of those facets of the new programs which involve the process dimension.

New procedures for evaluation must be found if the new science programs are to be successful.

The Department of Elementary Education at the University of Alberta has initiated a systematic program for the measurement of process skills through the elementary grades, using a direct approach. The first two phases of this program, involving the processes of classification and quantification have been completed by Blackford (1970) and Kellough (1971) respectively. The present study is a continuation of this program and involves a third basic process of science, the ability to "infer".

With regard to process skills Blackford and Wilson (1970) have asked the following questions: (1) How can we go about measuring the ability of the pupil in each process skill? (2) At what stage in his development is the child able to handle such processes? (3) At what stage does formal training in each process cease to be necessary?

The answers to these questions, which are of considerable importance to science educators, can hopefully be arrived at, in part, by the current series of studies of process in general, and by the

present study of inferential behavior of elementary students in particular.

THE PURPOSE

The purpose of this study was to determine the abilities of students from grades one through six with respect to their ability to draw inferences from observation. More specifically, the following was attempted:

1. To discover the present level of the ability to infer of a sample of children in each of three I.Q. groups in each of the grades one through six.

2. To discover the relationships, if any, between the ability to infer and grade level, I.Q., sex and age.

3. To identify difficulties students encounter in drawing inferences from observation.

4. To evaluate the growth of the ability to infer in students from grades one through six.

5. To specify the relationships between a child's ability to use visual clues as opposed to auditory-haptic clues when drawing inferences from observation.

SIGNIFICANCE OF THE STUDY

With the new emphasis in elementary science on the development of process skills, on inquiry, and upon problem solving abilities, much basic information is required with regard to intrinsic abilities and developmental patterns with respect to these important skills. If

students are to be evaluated on the basis of their acquired process skills then research dealing with the development of these skills is essential.

It is hoped this study will:

1. Provide teachers with criteria by which they may judge the inferential abilities of students in grades one through six.

2. Indicate at which grade levels an emphasis on the inference process may be most productive and beneficial.

3. Indicate any relationship that might exist between inference abilities and: (a) age, (b) grade, (c) sex, (d) general intelligence, (e) verbal ability, (f) spatial relations ability, (g) numerical ability, (h) reasoning ability, and (i) perceptual speed ability.

4. Indicate particular problems students encounter in carrying out inferential tasks.

5. Suggest possible verbal patterns that students use in drawing inferences.

6. Possibly serve as an aid in the construction of written inference tests.

DEFINITIONS

1. Inference Ability. The ability to draw conclusions concerning the nature of, or underlying causes for, a phenomenon or event based upon observation of the phenomenon or event and upon reflection regarding the observation.

2. <u>Visual Inference Task</u>. A task in which the inference drawn is based upon visual observation of a phenomenon or event.

3. <u>Auditory-Haptic Inference Task</u>. A task in which the inference drawn is based upon observations involving sound (auditory) or touch (haptic) events associated with a phenomenon.

4. <u>Intelligence</u>. Intelligence has been designated as low, average, or high according to the score obtained on the S.R.A. <u>Primary Mental Abilities</u> 2-4 Test (Grades 1, 2, 3) or 4-6 Test (Grades 4, 5, 6).

For the purpose of this study and on the basis of percentile norms provided by S.R.A., students from the first to thirty-third percentile in each grade will be designated as the low I.Q. group for that grade, students from the thirty-fourth to sixty-seventh percentile in each grade will be designated as the average I.Q. group for that grade, and students from the sixty-eighth to ninety-ninth percentile in each grade will be designated as the high I.Q. group for that grade.

5. <u>Verbal Ability</u>. Refers to the score obtained by the subjects on the 'Verbal Meaning' subtest of the S.R.A. <u>Primary Mental Abilities Test</u>.

6. <u>Spatial Relations Ability</u>. Refers to the score obtained by the subjects on the 'Spatial Relations' subtest of the S.R.A. <u>Primary Mental Abilities Test</u>.

7. <u>Numerical Ability</u>. Refers to the score obtained by the subjects on the 'Number Facility' subtest of the S.R.A. <u>Primary Mental Abilities Test</u>.

8. Reasoning Ability. Refers to the score obtained by the subjects on the 'Reasoning' subtest of the S.R.A. Primary Mental Abilities Test.

9. Perceptual Speed Ability. Refers to the score obtained by the subjects on the 'Perceptual Speed' subtest of the S.R.A. Primary Mental Abilities Test.

HYPOTHESES

1. (A) There is no significant relationship between visual inference scores and auditory-haptic inference scores.

(B) There is no significant relationship between each of these inference scores and: (a) grade, (b) age, (c) sex, (d) general intelligence, (e) verbal ability, (f) spatial relations ability, (g) number ability, (h) reasoning ability, and (i) perceptual speed ability, [(d) through (i) being determined on the basis of the S.R.A. "Primary Mental Abilities Test"].

2. There is no significant difference between boys and girls in:

(a) visual inference task score,

(b) auditory-haptic inference task score,

in each of the grades one through six.

3. There is no significant difference between grade levels in:

(a) visual inference task score,

(b) auditory-haptic inference task score,

from grades one through six.

4. There is no significant difference between low, average, and high I.Q. students in:

(a) visual inference task score,

(b) auditory-haptic inference task score,

in each of the grades one through six.

5. There is no significant interaction between grade level and I.Q. with respect to:

(a) visual inference task score,

(b) auditory-haptic inference task score.

6. There is no significant interaction between grade level and sex with respect to:

(a) visual inference task score,

(b) auditory-haptic inference task score.

7. There is no significant interaction between I.Q. and sex with respect to:

(a) visual inference task score,

(b) auditory-haptic inference task score.

LIMITATIONS

1. The students in the sample will not all have been involved in the program outlined in the 1969 science curriculum for the same period of time. Some have been involved for a maximum of four years while others will have been involved for periods ranging from one to three years. Thus, the results obtained from this investigation may differ from those which might be obtained from a similar investigation conducted after the curriculum has been in effect for six years.

However, as our principal concern is the study of a representative sample of the school population, "as it actually is", this matter need not cause us too much concern.

2. The students' prior experience or background was not considered in this study.

3. The inference tasks used have construct validity but no attempt was made to validate the tasks by using some external criterion measure. The reliability of the visual inference task was determined but no attempt was made to determine the reliabilitv of the auditory-haptic inference task.

4. Although every effort was made to standardize procedures in administering and evaluating each inference task, experimenter bias may have influenced the evaluation and administration of the tasks.

5. The schools selected for this study were not selected at random but were chosen by their respective administrations. This could mean that a representative sample was not obtained and this should be carefully considered when generalizing any of the results with respect to other populations.

6. Individual teachers may have varied considerably in their approach and ability in teaching the new science program. This variation could be reflected in the performance of their students in attempting the tasks involved in this study.

7. It is most difficult, if not impossible, to determine, account for, and control <u>all</u> of the variables that might influence the results of this study.

OVERVIEW OF THE STUDY

The nature of the problem under investigation having been presented, a review of the literature related to the study will be presented in Chapter 2. Chapter 3 contains a detailed description of each aspect of the experimental design, the methods and materials used in the study, and the statistical analysis used to test the hypotheses. The results of the analysis of data are reported in Chapter 4, together with a descriptive analysis of performance on the instruments used. Finally, a summary of the results of the study, including conclusions, implications and suggestions for further research is presented in Chapter 5.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Research literature pertaining to this study will be discussed under two main headings: general research related to the development and evaluation of process skills and research specifically related to the inference process.

PROCESS SKILLS

Since the origin of civilization each "age" has created peculiar problems which have posed challenges to existing teaching methods (Murphy, 1968).

Challenges of this nature continue to arise and, in elementary science, the latest challenge is associated with the introduction of a process-centered approach to teaching. Although many reputable educators (Burns, 1970) subscribe to the process approach in teaching science, some educators (Ausubel, 1965) still maintain that a science program must have as its main concern the presentation of an organized body of knowledge as an explicit end in itself. The present literature does not reveal any empirical evidence to support the view that either a "content centered" or a "process centered" method of teaching elementary science is superior, although there happens to be a great amount of testimonial literature in support of each approach.

Why the process approach then? Although much agreement exists among educators and scientists as to what the objectives of science education should be there is little common acceptance of the manner in

[illegible]

which the objectives of science education may be achieved. Three main views concerning the basis of a rationale relating child, adult and the scientific enterprise prevail: the first approach focuses on content and suggests that the teaching of science be based upon the concepts or unifying ideas of science - with a progression in teaching from the simple to the more complex and sophisticated concepts. A systematic approach to the transmission of scientific data to children is advocated by those who support the content view. The difficulties inherent in this approach are, of course, connected with the tremendous amount of information which must be acquired for the successful attainment of the objectives of such a program.

The second approach to the teaching of science involves 'creativity'. The proponents of this view suggest that teachers of science should be training children to be creative 'problem solvers'. Studies have shown that children who have been encouraged to pursue the problem-solving approach in their scientific endeavours, who are taught to restate the problem in their own words, to formulate critical questions and to generate new ideas, have shown a tendency toward this same behavior when presented with entirely new problems (Crutchfield and Covington, 1963). However, as Gagné points out, there is no evidence available to suggest that one can speak of a trait of creativity in an individual that is independent of other human abilities (Gagné, 1964).

The third approach to science teaching involves the 'processes of science' in teaching the children the things that a scientist does as he goes about his work. (See Appendix A) The 'process'

approach favors the idea of having children learn generalizable process skills which can then be applied in and across many subject areas. An associated notion is that 'creativity' can be developed and encouraged within the context of this process approach.

According to Gagné the basic premises of the 'process' approach are as follows:

1. The scientists' behaviors constitute a highly complex set of intellectual activities which can be broken into simpler activities.

2. These intellectual activities or processes can be learned, beginning with the simplest and progressing through the more complex activities.

3. These intellectual activities or processes are generalizable across scientific disciplines.

4. A sequence of instruction for acquiring the process skills can be constructed.

5. Such instruction will not necessarily give the student a strong background in any one content area but will give a general understanding of science with an ability to grasp and study scientific phenomena in general (AAAS Commission on Science Education, 1965, p. 4).

The key idea underlying the process approach is that of the progressive building of complex intellectual processes from simpler processes.

Modern psychological studies of learning and of the transfer of training show that high degrees of transfer or generalizability are not produced by practice within the confines of a narrowly defined task.

Studies in conceptual development in children also indicate that the growth of scientific concepts and logical thinking involves more than just practice of procedures.

In order to maximize the learning of processes Gagné says two main and necessary conditions must be met:

1. Practice of performance relevant to each newly acquired knowledge should involve the use of a wide variety of materials in many different situations.

2. Overt activities required of the student should be produced from the individual's own internal processes, rather than being tied to specific stimuli provided by the teacher (AAAS Commission on Science Education, 1965, p. 12).

It can be concluded from these statements that Gagné feels that there are basic types of broad "knowledges" that underlie the practice and understanding of science. Such knowledge or processes are generalizable with respect to all areas of science. One such basic process is 'inference', the process which will be dealt with in this study.

Recently, great emphasis has been placed upon the inquiry and process approach towards the teaching of science in North America in general and in Alberta in particular. The Elementary School Curriculum Guide (1969) states:

> The new elementary school science program has two fundamental but inseparable objectives. By emphasizing the development and use of inquiry skills as tools of investigation, the program is designed to enable the student to become an active and dynamic investigator of science. To have the student develop basic science concepts is a second aim (p. 5).

Revolutionary changes in education often create vacuums. Sudden change in direction or approach in a program may lead to uneven development of individual elements of such a program, leading possibly to the development of gaps and discontinuities in the program as a whole. The shift in emphasis in science teaching is a case in point. Although rapid progress is being made in the development of techniques for teaching process, a void has developed in evaluation procedures (Munson, 1967). Teachers must re-examine their measurement procedures and evaluation techniques in the light of the new curricular goals if they wish to be able to evaluate the effectiveness of instructional procedures in their progression towards the stated goal which is the development in students of the ability to critically analyse problems and produce ideas which contribute towards their solution (Smith, 1969).

The gravity of the problem facing us stems from the fact that very little research dealing with skill development at any level of education has been accomplished to date. If the process approach is considered important and if students are receiving training in these processes, it seems obvious that information regarding the effectiveness of various instructional procedures and the acquisition of process skills is desirable (Hungerford, 1969). This information, however, is not easy to obtain as Lisonbee (1966) has pointed out:

> With the emphasis in the newer science programs on the processes as well as the product of science, measurement of achievement is indeed a problem (p. 28).

Evaluation of process becomes much more difficult because of the problems involved in defining objectives in terms of student behavior (Tannenbaum, 1964). Clarification of a number of areas related to

'processes' are necessary as Burns and Brooks (1970) emphasize:

> We need to know a great deal more about which processes are important in learning, exactly what each process is, examples of processes in action, behaviors associated with each process, curricular activities associated with process learning, age-grade levels at which processes can be developed,* transfer values of processes, and the relative permanency of processes after they are learned (p. 28).

The development of measuring instruments capable of yielding data which would reveal whether or not students have indeed gained greater facility in the scientific process skills poses a major problem. This is exemplified by the fact that many of the "new process approach" elementary science programs have neglected to develop any evaluation instruments. Therefore, the construction of valid, of reliable, and of practical procedures that can be used routinely by the teacher for assessing student progress is of paramount importance.

There have been some attempts at developing tests for assessing student understanding of the science processes and their application. Two of these were developed by Butts and Jones (TAB Science Test, 1966) and Nelson and Mason (A Test of Scientific Comprehension, 1963). These tests do assess children's knowledge of science process to some extent but the tests are limited to upper elementary use and are, therefore, of limited value in looking at progress or ability on a grade one to six basis.

Dietz and George (The Problem Solving Skills Test, 1970) have developed a reliable and valid group test that evaluates some of the

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*Underlining by this writer.

science problem-solving skills of children in grades one, two and three. Jean Beard (Basic Science Process Tests, 1970) has developed a group achievement test for two of the basic processes of "AAAS Science - A Process Approach". The tests were for use at the primary level and they tested the ability to measure and classify. The test was validated by a critical jury and reliabilities were then estimated by correlating the test and re-test results.

The important area of pre-testing is often ignored by the classroom teacher. If the acquisition of science processes is hierarchical in nature (Gagné, 1962), then pre-assessment is as important as post assessment, although the majority of teachers do not include pre-teaching evaluation in their unit plans. The kind of evaluation employed by teachers usually has a verbal bias, and is often confined to the recall of specific information (Perkes, 1969; Stauss, 1970).

It appears obvious, therefore, that a great need exists for methods of assessing process abilities. The important question that must be asked is what form should such an assessment take. Munson (1967) states:

> Obviously, it is impossible to evaluate objectively all phases of learning in the modern science program. It is impossible to quantify all evidence of progress. A teacher's first step is to admit that much evaluation of skill development must be subjective (p. 29).

Although there is some truth in this it would appear that little real progress can be anticipated if subjective evaluation methods are employed exclusively although many such techniques have been suggested (Dunfee, 1957).

Practical tests which measure abilities directly must be developed to replace those tests which involve factual recall only. The latter tests often incidentally involve reading speed and comprehension, a factor which tends to distort the true significance of the results obtained.

INFERENCE PROCESS

Piaget has been particularly concerned with the establishment of the precise relationship between the classifications made by children and the kinds of inferences that they make on the basis of these classifications (Inhelder and Piaget, 1964, p. 11). Thus, a more thorough discussion of research on classification and its relation to inference and problem-solving is warranted.

A major part of the ability to infer depends upon the ability to render classification unambiguous in nature which, in turn, depends upon an ability to recognize and define criteria upon which classifications may be based. That is, reasoning (inference) and the ability to abstract criteria for classification are directly related (Inhelder and Piaget, 1964).

According to Piaget there are two levels of inference: one relating to logical reasoning as it pertains to classification and seriation, the other relating to hypothetico-deductive reasoning (Inhelder and Piaget, 1964, p. 20). Piaget maintains that logical reasoning develops before hypothetico-deductive reasoning, a definite distinction being made between the two levels of inference. Children of four or five rarely justify their predictions and at six years of age the child appears to use experience and sense of purpose in a rather

unsystematic approach towards reasoning related to their predictions. By the age of seven or eight contradictions begin to be eliminated and children are able to reason or infer by referring to some poorly established concepts. At the age of nine and ten, children are quite able to refer directly and unambiguously to the reasons for the occurrence of certain situations, events or phenomena. Although these children are able to predict with a certain amount of accuracy it is not until they are about thirteen that they can determine why things behave as they do.

The significance of classification with respect to inference is indicated by Piaget's important work with seven to nine year old children (Inhelder and Piaget, 1964, p. 21). The children studied in this age range were able to group objects on the basis of relative size and weight. They were then able to draw inferences with respect to density, on the basis of such classificatory criteria.

Piaget describes three stages of development which a person goes through in developing classification abilities. Stage I in this development occurs from about two years to five years of age and is known as the "Stage of Graphic Collections". At this stage children do not arrange objects in collections and sub-collections on the basis of similarity alone as they are unable simultaneously to overlook the spatial arrangement of the objects, similarity and spatial arrangement being united in "graphic collections". No progression in development appears to be detectable within the stage of graphic collections although this stage invariably precedes Stage II, that of "Non-Graphic

Collections".

This "Stage of Non-Graphic Collections" involves children of the six to eight year age range and involves a developmental stage which permits the children to assign objects to a collection (classify) on the basis of similarity alone. The major difference between children in this stage and Stage III, the "Stage of True Logical Classification" is the advent of class inclusion a feature absent from Stage II. Stage II children do not understand the "all" and "some" conditions of class inclusion and they often judge a part to be greater than the whole.

Stage III, which develops around the child's eighth year incorporates true classification ability and involves the use of all ten of the classification criteria listed by Inhelder and Piaget (1964, p. 48). Individuals have often reached Piaget's stage of formal operations before they completely understand true classification, an understanding of class inclusion coming with conservation of the whole and quantitative comparison of the whole with the part. Class inclusion is in fact operational in nature and is the basis of any classification which orders classes instead of only differentiating between them.

Piaget's analysis of the developmental stages in classification behavior and the associated mechanisms involving perception and sensorimotor behavior can be summarized as follows:

1. There is a very close relationship between the development of logical operations and sub-logical operations.

2. The reason for the appearance of a stage of graphic

collections is due to the situation that young children have difficulty in coordinating intension (the properties common to members of a given class) and extension (the ability to define the members of a given class).

3. The central problem in the development of classificatory behavior is the coordination of extension and intension.

4. The transition between Stages I and II is controlled by the development of hindsight and anticipation. The further development of these abilities lead to the reversible operational structures of Stage III at which point one is able to understand the relation of inclusion.

5. Logical operations (classification and seriation for example) are closely linked with certain elementary actions such as separating piles into lots. Piaget states with regard to logical operations:

> The development is astonishingly continuous; after the actions we have various adjustments to these actions and these in turn become increasingly complex so that in time the entire process is interiorized and generalized (Inhelder and Piaget, 1964, p. 291).

The process of inference (as it related to logical reasoning) develops on a parallel basis with that of classificatory behavior. An understanding of the stages involved in the development of classificatory behavior thus enables us to understand the development of inferential behavior in children as well.*

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*For a more comprehensive discussion of Piaget's work with classificatory behavior see Blackford, 1970.

F. C. Bartlett has stated that:

> Whenever anybody interprets evidence from any source, and his interpretation contains characteristics that cannot be referred wholly to direct sensory observation or perception, this person thinks (in Bruner, 1957, p. 41).

Bruner accepts this statement as he discusses ways in which one goes beyond information that is given. The simplest form of utilizing inference is expressed in learning the defining properties of a class of equivalent objects and then using these properties as a basis for deciding whether a new object encountered is or is not a member of the original class.

A second form of going beyond the information given is in the learning of the probabilities of certain situations arising in the environment and then progressing to a prediction of likely concomitants.

Another form of inference is exemplified by the transitive property: $A > B$, $B > C$, $A > C$. A person codes information in this way according to certain coding systems. Similarly formal codes and probability codes are often combined in making inferences which go beyond the original data given (Bruner, 1957).

Bruner defines a coding system as a "set of contingently related, nonspecific categories", that is, the manner in which a person groups and relates information about his world (Bruner, 1957, p. 46). When one goes beyond given information one does so by classifying the given according to a more "generic" coding system and then "reading off" from the coding system additional information on the basis of learned contingent probabilities or learned principles of related material.

Four important conditions must be considered in maximizing the transferability of learning to new situations by coding something in a generic manner. The first of these, learning set, has a major bearing on the ability of one to code newly learned knowledge. As Bruner, Goodnow, and Austin (1955) found in an extensive number of experiments, the search for a generic code leads to certain learning sets that are absent when the task is seen as purely one of memory. Instructions act as a set producer that brings forth different forms of coding which are appropriate to the situation.

Studies of need state and the acquisition of coding systems by researchers such as Klein, Wertheimer, Tolman, Harlow, and Postman and Bruner (in Bruner, 1957) have generally shown that a high need state causes an organism to deal with the here and now with little regard for the significance of what is being learned.

The third set of conditions which need consideration is the degree of mastery from which a more generic coding system may be derived. Mastery of the specifics must be sufficient to allow for the discovery of lower-order regularities which can then be re-combined into higher order coding systems.

Diversity of training is important in that exposure of an individual to change seems to stimulate genericizing (Bruner, 1957). The impact of diversity of training together with the conditions outlined above needs to be examined in much greater depth in the context of classification, coding and the ability to infer.

Inference and the Perception-
Conception Relationship

The interrelation between perception and thinking has been conceptualized in various ways and no single, acceptable characterization of this relationship is extant.

Three widely differing views on the relationship between perception and conception will be discussed, the first of these being the Gestalt position. Basically, the Gestaltists take a mode of perception and attempt to fit it into the area of thinking. As Koffka states:

> . . . the ideational field depends upon the sensory, and any means that enable us to become independent of immediate perception are rooted in perception, and, in truth only lead us from one perception to another (in Kessen, 1962, p. 88).

The Gestaltists do not consider concept formation or symbolic processes when discussing restructuring of the field. Also, they do not show any concern for developmental changes in the behavior of children.

Bruner's position, which is in opposition to that of the Gestaltists, is that perception is basically an inferential process in which the perceiver plays a major role in interpreting, categorising or transforming the stimulus input. He suggests that a theory of perception needs a mechanism capable of inference and categorizing as much as does a theory of cognition. Perceptual learning requires a system of categories to which stimulus input can be matched. For example, in a study by Potter, pictures of objects were presented, out of focus, to subjects. As each picture was

gradually brought into focus the subjects were asked to guess what object was pictured. The results showed that perception consisted of a process of cue searching, inference and matching (in Bruner, et al., 1966).

One of the problems with Bruner's model of perception is however that he, too, has neglected to consider the developmental aspects of perception and thinking.

The third position to be considered is due to Brunswik who emphasized the difference between perception and thinking. In discussing this difference Brunswik (1956) comments:

> The entire pattern of reasoning solutions . . . being well organized and of machinelike precision. On the other hand . . . perception must simultaneously integrate many different avenue of approach, or cues (p. 91).

Brunswik goes on to suggest that cognitive mechanisms intervene as an individual develops and thus lessen the need for precise perceptual achievements.

Piaget's view is that developmental changes occur in intellectual, but not in perceptual development. This view is exemplified by a study in which two parallel lines forming the top and bottom of a parallelogram were judged as being less equal in length more often by eight year olds than by five year olds. When the same two lines were presented in the context of a cognitive task it was the five year olds who showed more frequent errors in their judgments. This study served as evidence in favor of Piaget's separation of perception and conception (or inference) (Piaget, 1956).

Piaget argues that there are "pre-inferences" in perception

which are partially isomorphic with the inferential mechanisms of logical reasoning. All judgment is thought to involve a decision process whereby an inference is made which is itself based on the sensory information given. The extent of this inference process depends upon the complexity of the judgment (Piaget, 1958).

Despite Piaget's own suggested link between perception and inference, he generally sees the two as sharply differentiated processes. Piaget also considers the development of perception and thinking as following unrelated courses. The most probable reason for this point of view has been attributed to the fact that development of perception provides none of the meaningful structural criteria needed for distinguishing among different stages (Wohlwill, 1962). The opposite is the case, of course, for conceptual development.

A rather useful way of looking at perception and conception is that established by Wohlwill who relates the two areas along the following dimensions:

1. Redundancy: As one proceeds from perception to conception, the amount of redundant information required decreases.

2. Selectivity: As one proceeds from perception to conception, the amount of irrelevant information that can be tolerated without affecting the response increases.

3. Contiguity: As one proceeds from perception to conception, the spatial and temporal separation over which the total information contained in the stimulus field can be integrated increases (in Kessen, 1962, p. 102)

These three dimensions produce responses of varying specificity

[illegible]

which range from perceptual judgment, where accuracy is only relative, to conceptual processes of absolute precision and accuracy. A developmental progression would appear to result as an individual moves from perception to conception along each of the three dimensions (Wohlwill, 1962).

Bartlett (1932) discusses a schema or classification of past experiences. Perception is mediated by this schema.

Vernon elaborated on Bartlett's schema with respect to perception. She says that schemata operating in perception tell the observer what sensory data to select from the total input, as well as how to deal with these data. Of perception in infancy and early childhood she states the following:

> . . . in the first place, it is vague and diffuse, lacking in accurate observation of detail and selection of what to us seem to be the significant aspects of the situation; and second, the child is relatively unable to make inferences from his immediate sensory perceptions of the nature of objects and of the environment because he lacks the knowledge to guide him (Vernon, 1966, p. 393).

Kendler and Kendler (1956, 1958, 1961) studied inferential behavior in preschool children. Their results showed that children of 3-4 years of age demonstrated inferential behavior on the basis of past training. In their 1958 study they found that inferential behavior is influenced by independent variations of reinforcement and by motivational variables. Furthermore, inferential behavior among preschool children is not influenced by the order of presentation of two discretely acquired behavior segments that were used in attaining a particular goal (Kendler and Kendler, 1961).

A thorough analysis of children's cause and effect responses to

simple experiments in physical science was made by Deutsche (1937) who found that boys and girls gradually progress in their ability to see causal relationships with advancing age and that many very young children also show surprising ability to see such relationships.

A study by Oakes (1947) revealed that there is no definite state in a child's thinking which is characteristic of a given age. He reported that, for a given age, types of answers to questions were influenced more by the nature of the problem, the wording of a question and the child's experimental background and vocabulary, than by any mental structure. Piaget's comments on these findings might prove to be very enlightening.

Butts (1966) determined that meaningful concept development will result once a child is given the proper environment to perceive and is then given free opportunity to experience certain perceptions and to merge these perceptions into concepts. This study also indicated that manipulation of data alone is insufficient for concept development.

In a study conducted by Scott (1966) it was discovered that the relationship of the strategy of inquiry to children's styles of categorization has a significant effect on the flexibility of their categorization behavior. Generally, students in grades 4, 5 and 6 taught by an inquiry approach, were able to classify or infer on the basis of manifest details and inferred attributes whereas students taught in a more traditional way could not infer to the same extent.

Taba (1966) in a manner somewhat similar to Gagné, describes five theoretical postulates about thinking:

1. Thinking can be taught if the specific processes and skills composing it are identified.

2. Thinking is an active transaction between the individual and the data in the program.

3. Processes of thought evolve by lawful sequence.

4. Growth in cognitive performance involves assimilation and accommodation.

5. Thought can be studied both as a psychological phenomenon and a logical system.

The above postulates were incorporated by Taba (1966) into a structure of three cognitive tasks. The second of these cognitive tasks was that of "inferring and generalizing" which includes detecting causal relations and making inferences. This task is preceded in the hierarchy by the task of "concept formation" and is followed by the task of "application of principles".

It seems readily apparent that the research into the general area of cognition and into the area of inference in particular provides no real consensus as to how one goes about going beyond the information given. The mean ideas and theories with respect to inference surely indicate the tenuous nature of knowledge concerning this important aspect of cognition.

CHAPTER 3

DESIGN OF THE STUDY

THE SAMPLE

The population from which the sample was selected consisted of all of the elementary students from six schools, two from each of the Edmonton Public, Edmonton Separate and County of Strathcona Number 20 School Systems. These schools were selected by administrators from each of the systems so as to provide a sample of students from a broad socio-economic and cultural background. A sample of one hundred and eight students, stratified on the basis of sex, was selected from these schools so that only eighteen students were drawn from each school. Two exceptions occurred in this general scheme: one school did not have any grade six students, so only fifteen students participated in the study from that school. Therefore, in order to balance the number of grade six students, a total of twenty-one students were selected from another school. Normally three students were selected from each grade in each school but in the case of the two exceptions noted, no grade six students were selected from one school and six grade six students were selected from another. The number of students to be selected from each grade was determined beforehand so that there would be a total from all schools of eighteen students from each grade when the testing was completed.

Each of the students was tested on the visual inference task but only sixty-four of the one hundred and eight students were tested

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

on the auditory-haptic inference task. The latter test group was made up of the following numbers: 12 students from grade two, 12 from grade three, 14 from grade four, 14 from grade five, and 12 from grade six.

The students were randomly selected from class lists of the appropriate grades. The amount of teacher or school bias in the study was minimized by the randomizing procedure. Table 1 summarizes the distribution of students in the sample.

INSTRUMENTATION

Inference Task

Theoretical Background. In order to achieve the objectives of this investigation, two individualized inference activities were designed which consisted of a visual inference task and an auditory-haptic inference task. These activities, while meeting the definition of inference described in Chapter 1, also had to meet other criteria such as those indicated in Kendler's (1958) description of inference as "part of that area variously called cognitive process, thinking or problem solving". She makes the following statement with respect to inference:

> Inference is defined as the spontaneous integration of discretely acquired habits to solve a problem. These processes have been reduced to some very simple operations in order to study them at their inception in young children. The operations are so simple that there may be some disagreement about their continuity with the high level process that they presume to study. The prepared reply to such potential objection is that there is no known way of reliably determining, on an *a priori* basis, the proper level of analysis for scientific research. It is only by its fruits that we shall know it (Kendler, 1963, p. 35).

TABLE I

DISTRIBUTION OF STUDENTS IN SAMPLE

System			Edmonton Public		Edmonton Separate		Strathcona County		Visual			Auditory-Haptic		
School			1	2	3	4	5	6	N Boys	N Girls	N Grade	N Boys	N Girls	N Grade
Grade One	Visual	M[a]	2	2	1	2	1	1	9					
		F[b]	1	1	2	1	2	2		9	18			
	Auditory-Haptic	M												
		F												
Grade Two	Visual	M	1	2	2	1	1	2	9					
		F	2	1	1	2	2	1		9	18			
	Auditory-Haptic	M			2	1	1	2				6		
		F			1	2	2	1					6	12
Grade Three	Visual	M	2	1	1	2	2	1	9					
		F	1	2	2	1	1	2		9	18			
	Auditory-Haptic	M		1	1	2	2					6		
		F		2	2	1	1						6	12
Grade Four	Visual	M	2	2	1	1	1	2	9					
		F	1	1	2	2	2	1		9	18			
	Auditory-Haptic	M		2	1	1	1	2				7		
		F		1	2	2	1	1					7	14
Grade Five	Visual	M	2	2	1	1	1	2	9					
		F	1	1	2	2	2	1		9	18			
	Auditory-Haptic	M		2		1	1	2				6		
		F		1	2	2	2	1					8	14
Grade Six	Visual	M	4		1	2	1	1	9					
		F	2		2	1	2	2		9	18			
	Auditory-Haptic	M			1	2	1	1				5		
		F			2	1	2	2					7	12
School N	Visual		21	15	18	18	18	18						
	Auditory-Haptic			9	14	15	14	12						
System N	Visual		36		36		36							
	Auditory-Haptic		9		29		26							
Total N	Visual				108									
	Auditory-Haptic				64									

[a]Male

[b]Female

[illegible]

The discretely acquired habits that Kendler (1963) mentions would compare with Bruner's 'categories'. These, then, would relate to the hierarchical development of intellectual processes around which Gagné (1965) builds his process approach. The two tasks used in this study required the children to rely on previous experience and upon their ability to make inferences, based on this previous experience, from observations the accuracy and effectiveness of which is also presumably based upon previous experience. The visual inference task was an activity that the children would not likely have experienced before <u>in toto</u> although all of the materials would have been familiar to most children. The auditory-haptic task involved objects which most of the children would have seen and/or heard previously. By structuring the tasks in this way it was hoped that the mobilization of true inference ability would be required on the part of each child for the completion of the set tasks.

<u>Materials</u>

1. <u>Visual Inference Task</u>. The stimulus device used for the visual inference task consisted of an "inference machine" (see Plate I, p. 33). This machine was constructed of balsa wood and glass. A balsa wood frame measuring 8" x 8" x 2" was constructed and a glass bottom, slanted at about 10° from the horizontal was set inside this frame. Small pieces of balsa wood measuring ½" x 2½" were used to create 10 slots running down the slope of the machine. An open area over which a balsa wood lid could be fitted was left in the center of the machine. Ten steel balls, 7/16" in diameter, completed the main

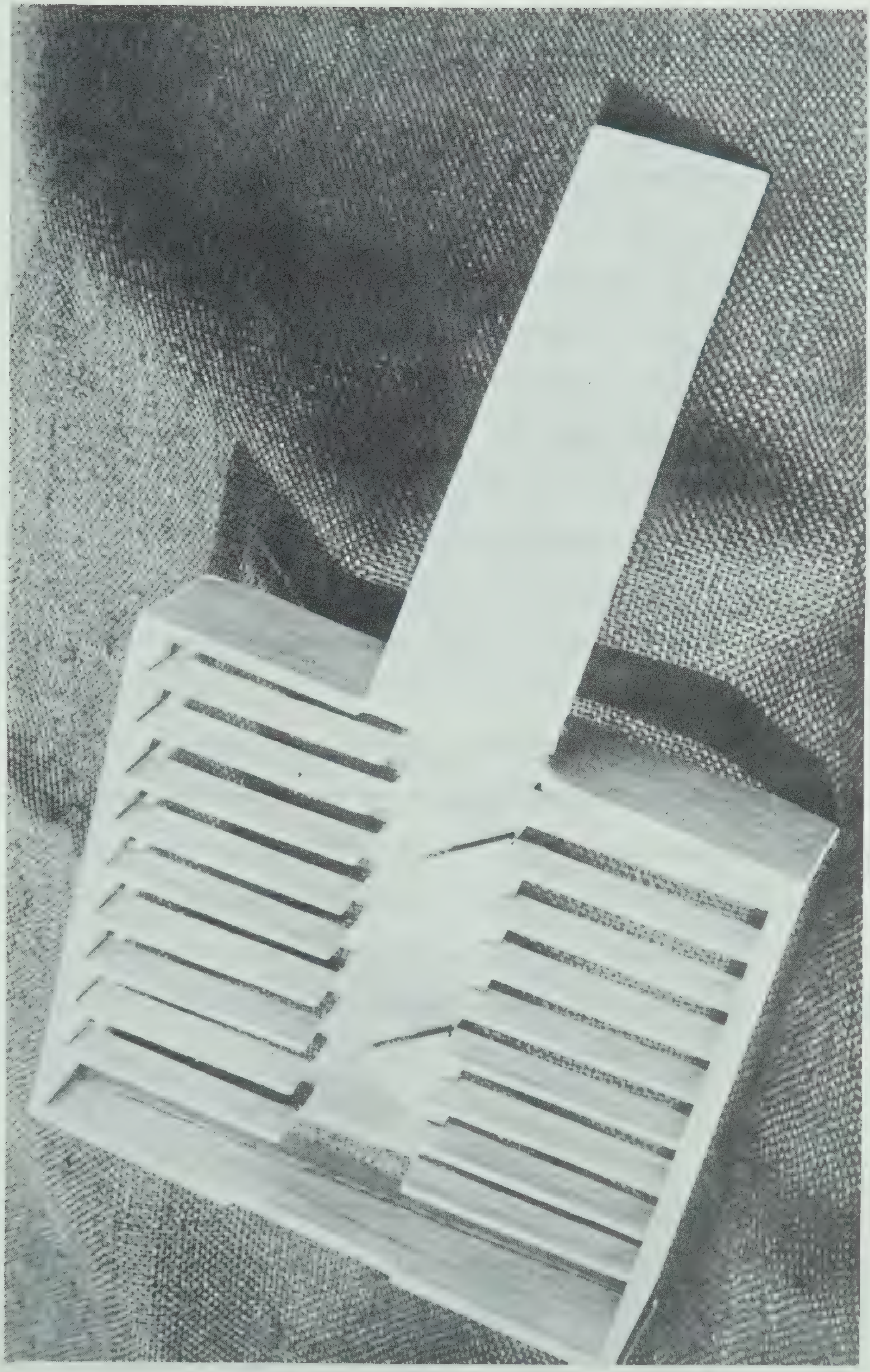

PLATE I

VISUAL INFERENCE TASK APPARATUS

part of the apparatus, the intention being that one ball could be rolled down each of the slots.

Two kinds of objects could be placed in the central area of the machine: 1) blocks of various sizes could be used to stop the passage of a ball from the upper to the lower end of the slot and 2) slopes could be used to divert a ball from the slots in which they were initially placed. Slopes were also of varying sizes and angles, such variations determining into which of the lower slots a ball was diverted. An opaque lid covered up the area where the block and/or slopes were placed so that the children could not see the nature or distribution of the blocks and/or slopes directly, but could only infer their position and nature from the distribution of the balls in the lower slots.

2. Auditory-Haptic Task. The stimulus materials used for the auditory-haptic task consisted of seven externally identical, sealed aluminum boxes measuring 8" x 8" x 8". Six boxes contained an object that would be reasonably familiar to the child with respect to its physical properties. The objects varied in size, composition, weight and shape. The seventh box was sealed but did not contain anything. (See Plate II, p. 35). The boxes and their respective objects were:

Box #1 - empty

Box #2 - rubber ball, 2" in diameter

Box #3 - heavy cardboard rectangular prism, 6" x 4" x 1"

Box #4 - light metal cylinder, 6' x 1/2"

Box #5 - roll of tape, 6" x 1/2"

Box #6 - plastic rectangular pyramid, 2" base x $2^1/_2$" high

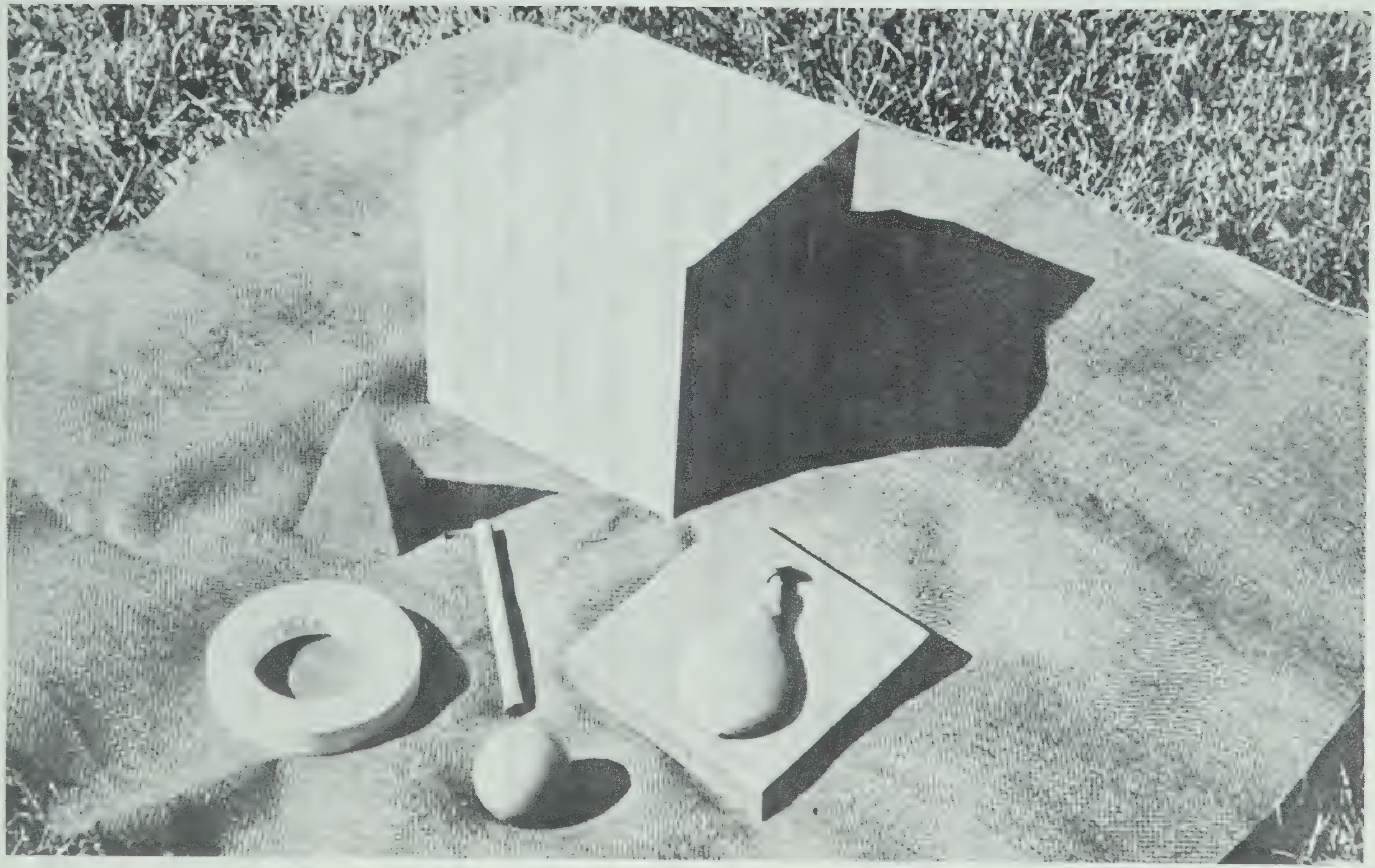

PLATE II

AUDITORY-HAPTIC INFERENCE TASK APPARATUS

Box #7 - balloon filled with mercury, approximately 3" across.

Procedures

1. Visual Inference Task. Each student was individually interviewed by the investigator, using a standard procedure, no set order for interviewing the students in each school being employed.

Each interview followed a common pattern. The children were all acquainted with the investigator as the I.Q. test had been administered on a previous occasion. The student's name, school, age and grade were indicated on the data sheet and the student was then shown the inference machine. A steel ball was dropped into each slot so that he could see how the machine worked, the opaque cover of the central area being open at this stage although blocks and slopes were not in place. The inference machine was then placed on an overhead projector, the image of the machine being projected on to the wall. Once again the balls were placed in the slots so the children could view the enlarged image of the balls rolling through the slots. The child was then made aware of the blocks and slopes although the blocks and slopes were not shown directly to the child but were placed one at a time in the machine in such a way that the children could not see them or their image on the wall. The lid was closed and the balls were placed in the slots in order that the child might see how a block or slope affected the movement of the balls. For a complete description of the instructional phase of this task see Appendix B.

The child was then shown the data sheet and told in general terms the nature of the kind of responses which were required. Each

child was asked first to indicate with a B or an S those slots that had either a block or a slope in the central zone. Then he was asked to draw, in the appropriate place on the data sheet (see Appendix C). what he thought each block or slope looked like. Eight patterns of blocks and/or slopes were presented in the same sequence to each student. A ball was rolled in each of the ten slots for each experimental block/slope arrangement. After observing the motion of the balls and faced with their final distribution pattern, the students were given as much time as they indicated they needed to complete their response for each pattern. In general this time requirement ranged from about 15 seconds to 2 minutes. The described format of presentation was rigidly adhered to in order to keep this facet of the task consistent.

2. Auditory-Haptic Task. Each of the sixty-four children who participated in this part of the investigation was again dealt with individually for the duration of the auditory-haptic task. A random order of interviewing was used, the interviews following a common procedure. Each child was greeted and then shown the seven identical aluminum boxes. He was told there were objects in six of the boxes and that he would be allowed to pick up each of these boxes and manipulate it as much as he wished in order to discover all he could about the object inside. Firstly though, each child was asked to pick up the empty box, which could be used for comparison with the other boxes. The child was then instructed to pick each of the other boxes in sequence and after manipulating each box, to tell the investigator all that he could about the object inside that box.

Responses for each object were recorded under eight categories (See Appendix E). After each student had responded spontaneously to the limit of his ability the investigator offered prompts relating to four of the eight categories: the way the object moved, weight, composition and sound. The prompt consisted simply of a mention of the category name with a pause so that the child could respond appropriately if able to do so. The same four categories were used in prompting each student for whom prompting was necessary. It was felt that the prompting would assist those students who were uncertain about the response that was required of them. Care was taken, however, to elicit as much information as possible from the students during the interview before prompting began.

Scoring

1. Visual Inference Task. The visual inference task was scored on the basis of the responses made by each student on each of the data sheets used. These student responses consisted firstly of indications of whether a block or a slope was responsible for each ball pattern and secondly upon a drawing of what the slope or block distribution looked like. The investigator allowed one point for each correctly identified block and/or slope and one point for each correctly drawn block and/or slope. A judgment had to be made by the investigator as to the correctness of each drawing.

Total scores for each pattern varied from four points for the first pattern to twelve points for the eighth pattern (See Appendix D).

Each individual interview carried out during the course of the visual inference investigation was tape recorded, the tape to be used for possible later analysis.

2. Auditory-Haptic Task. The scoring procedure used for the auditory-haptic task was a modification of that used for the Illinois Test of Linguistic Skills. For each of the eight descriptive categories used for each object one point was allowed for each non-redundant response. Non-redundant responses were indicated by a separate group of words beginning with a capital letter in the 1-point column (see Appendix E). Responses in each word group which were separated by commas were redundant and credit was allowed for only one term in each group. A judgment was made by the investigator as to the suitability of responses given which did not appear on the data sheet.

A tape recording was made of each interview in order to provide a supplement to the written record and also to provide data for further analysis of the students' responses and language patterns.

Other ways of scoring were considered for each inference task but, as Kellough's study has shown that four widely different scoring procedures yielded highly correlated results, it was decided to regard the system outlined as being representative of the scoring ability of the students for this task. This rather arbitrarily chosen scoring system seemed to be as satisfactory as any for the purposes of this study (Kellough, 1971).

I.Q. Scores. I.Q. Scores were obtained for all of the students involved in the study by administering a common intelligence test during the month of May, 1972. The primary grades were tested by means of the S.R.A. Primary Mental Abilities Test for grades two to four and the upper elementary grades were tested using the S.R.A.

Primary Mental Abilities Test for grades four to six.

I.Q. testing was found to be necessary because each of the three school systems used different intelligence tests and administered them to different grades at different times of the year. This made any kind of comparison very difficult and of little meaning, as Blackford (1970) indicated in his study.

The S.R.A. Primary Mental Abilities Tests for grades two to four and grades four to six were chosen for three reasons. First, none of the three school systems involved in the study had administered these tests to their students. Secondly, the general intelligence quotient in the S.R.A. test is subdivided into five factors of intelligence or "primary mental abilities", which include: verbal meaning, number facility, reasoning, spatial relations ability and perceptual speed ability, each being measured on a separate subtest. Finally, it was felt that each subscore might be important in indicating which factors of general intelligence are important with respect to inference ability.

RELIABILITY

The reliability of the visual inference task was determined by means of an analysis which was carried out by using the ANOV14 IBM 360/67 computer program. This program permits the statistical analysis of a single factor experiment with repeated measures.

Fifty-four students, or one-half of the sample, were involved in the repeated measures, the first, third, fifth and seventh items of

the visual inference task. These items were presented to each student immediately following completion of the total visual inference task and at the completion of the repeated measures several students were questioned as to whether they recognized the patterns which they repeated. All of them replied in the negative. Table II contains a summary of the reliability data.

It should be noted that the mean score for the repeated measures was .95 greater than that for the initial task. This increase may be attributed to the experience factor which each student acquired. This last assertion may be made with some degree of certainty because of the rather large value which was obtained for the reliability coefficient, 0.965.

No attempt was made by the investigator to determine the reliability of the auditory-haptic inference task.

VALIDITY

Content Validity. The two inference tasks, visual and auditory-haptic, would appear to have face validity based on a subjective evaluation of what they measure. In new areas such as that of process evaluation there is very little else to rely upon in determining content validity (Helmstadter, 1970).

Construct Validity. No single numerical estimate of the degree of construct validity can be found. Therefore, a wide variety of approaches and evidences supporting claims about what a test measures must be used.

The construct validity of both the visual inference task and the auditory-haptic inference task was based on the following evidence:

1. A high correlation coefficient was found between scores on the visual inference task and the auditory-haptic inference task.

2. A study of the testing process indicated valid tasks were being administered.

A measure of criterion-related validity was not attempted because of the apparent lack of such a criterion with which to compare either of the inference tasks.

TABLE II

RELIABILITY CORRELATIONS FOR REPEATED MEASURES ON THE VISUAL INFERENCE TASK

	Patterns 1, 3, 5, 7	Repeated Patterns 1, 3, 5, 7
Mean	16.98	17.92

Adjusted Reliability (RK) = 0.965.

PILOT STUDY

In order to maximize the efficiency of the main study a pilot study was carried out in February, 1972, with children from a school not involved in the main study.

The pilot study for the visual inference task included seventy children, twelve children being chosen from grade one, three children from grade two, twenty-one children from grade three, three children from grade four and thirty-one children from grade six.

The auditory-haptic pilot study included fifteen children. Three children were selected from each of the grades one, two, three, four and six.

The pilot study was undertaken to determine:

1. The approximate time needed for children to complete the inference activities.

2. The type and amount of instruction needed in order to have the two inference tasks understood by children in each grade.

3. The feasibility of presenting the designed inference tasks to grade one through six children of a broad range of abilities.

4. The likelihood of finding significant differences in performance with respect to these tasks through the grades tested.

5. Administrative problems that might arise during the testing.

The results of the pilot study are shown in Tables IIIA and IIIB.

On the basis of the results obtained from the pilot study it was decided that :

1. The approximate time needed for completion of the visual

TABLE IIIA

MEAN SCORES BY GRADE ON VISUAL INFERENCE TASK (PILOT STUDY)

Grade	1	2	3	4	5	6
Visual Inference Score	24.8	69.5	71.0	80.6	-	91.2

TABLE IIIB

MEAN SCORES BY GRADE ON AUDITORY-HAPTIC INFERENCE TASK (PILOT STUDY)

Grade	1	2	3	4	5	6
Auditory-Haptic Inference Score	17.5	20.4	24.3	26.0	-	26.3

inference task was thirty minutes for each grade one student, decreasing to twenty-five minutes for each grade six student. The auditory-haptic inference task required approximately twenty minutes for each student from grades one through six.

2. The initially formulated verbal instructions were found to be inadequate for the visual inference task. The investigator found it necessary to show the children how a 'block' and a 'slope' affected the balls. It was also found to be necessary to allow the children to familiarize themselves fairly completely with the inference machine prior to administration of the task.

Verbal instructions were found to be adequate for the auditory-haptic inference task.

3. Children from all of the grades, one through six, were able to attempt each of the tasks with little difficulty. However, one fewer box than originally intended was used for the auditory-haptic inference task due to weariness manifested by some of the younger children after manipulating several of the boxes in sequence.

4. An obvious increase in inference score was evident through the grades one through six for both the visual inference task and the auditory-haptic inference task.

5. It was found that the individual interview approach to each inference task was preferable to any form of group approach to the task.

6. A small private room with one wall suitable for projection purposes was found to be adequate for the pursuit of the investigations. In addition, a high stand for the overhead projector was found to be

desirable as this allowed the investigator to conceal the blocks and slopes from direct view. A long table was found to be of help in administering the auditory-haptic inference task. A table and chair or desk was needed for the student and an electrical outlet was necessary for the equipment used in each of the inference tasks.

THE TESTING PROGRAM

The main testing program was carried out between April 24 and June 2, 1972. The investigator travelled to each of the six schools and administered the two inference tasks individually to each student involved. Appointments were made with each school in such a way as to least disturb the regular school program.

The times involved for the completion of the various phases of the total program are indicated in Appendix I.

TYPES OF DATA ANALYSIS USED

The variables of hypothesis #1, with the exception of the sex variable, were subjected to Pearson Product Moment Correlations in order to determine their relationship, if any, with both the visual inference scores and the auditory-haptic inference scores. The significance of existing relationships was measured by a test for probability carried out by means of the DESTØ5 IBM 360/67 computer program. To determine the relationship of the sex variable to each of the inference scores a point biserial correlation was calculated. The 0.05 level of significance was used as a basis for acceptance or

rejection of each correlation.

Hypotheses #2, #3, and #4 were subjected to a one-way analysis of variance. Hypothesis #2, which compared boys scores with girls scores, was analysed by means of a "t" test computed by means of the ANOV1Ø IBM 360/67 computer program. The decision regarding acceptance or rejection of this hypothesis was made at the 0.05 level of significance.

Hypotheses #3 and #4 were analysed by means of the ANOV15 IBM 360/67 computer program. This program carries out a Scheffé multiple comparison of means. The 0.10 level of significance was used as the criterion for acceptance or rejection of these hypotheses. This rather low level of significance was chosen because of the extremely rigorous nature of the Scheffé procedure, the 0.10 level having been suggested by Scheffé (Ferguson, 1971, p. 271).

Hypotheses #5, #6, and #7 were subjected to a two-way analysis of variance in order to determine the significance of the interaction, if any, between grade and I.Q., grade and sex, and I.Q. and sex. This interaction was measured by means of a test for additivity carried out by implementation of the ANOV25 IBM 360/67 computer program. The 0.05 level of significance was used as a basis for acceptance or rejection of these three hypotheses.

CHAPTER 4

RESULTS OF THE INVESTIGATION

The results of the statistical analysis which yielded data on each of the hypotheses will be presented in this chapter together with analysis of variance tables, cell means matrices and probability matrices. The calculations for the statistical analysis were carried out by means of the IBM 360/67 analysis of variance and 'Pearson Product Moment' computer programs. These programs have been documented and tested by members of the Division of Educational Research Services of the University of Alberta.

STATISTICAL ANALYSIS OF THE HYPOTHESES

Hypothesis #1

A) There is no significant relationship between visual inference task scores and auditory-haptic inference task scores.

B) There is no significant relationship between each of these inference scores and: (a) grade, (b) age, (c) sex, (d) general intelligence, (e) verbal ability, (f) spatial relations ability, (g) number ability, (h) reasoning ability, and (i) perceptual speed ability [(d) through (i) being determined on the basis of the S.R.A. "Primary Mental Abilities Test"].

The purpose of this hypothesis was to determine if any degree of relationship existed between the two inference scores and each of the variables indicated in the hypothesis. Such relationships, if they exist, could be useful in predicting inference ability scores for

other children taken from the same population as the sample for this study. This hypothesis was analysed by means of the 'Pearson Product Moment' correlation technique which was calculated by utilizing the DESTØ5 IBM 360/67 computer program. The DESTØ5 IBM 360/67 program was used for all variables except the sex variable which was analysed by means of the 'point biserial' correlation technique discussed in Ferguson (1971, p. 271).

Results: The correlations between the two inference scores and between each inference score and the variables specified in hypothesis #1 are presented in Table IV. A significance level of 0.05 was chosen for accepting or rejecting the hypothesis. Scores obtained from the visual inference task were found to correlate significantly with those from the auditory-haptic inference task. The variables age, grade, general intelligence, verbal ability, spatial relations ability, numerical ability, reasoning ability and perceptual speed ability were found to correlate significantly with the scores obtained on the visual inference task. The variables age, grade, general intelligence, verbal ability, spatial relations ability, and numerical ability were also found to correlate significantly with the auditory-haptic inference task scores. Therefore, hypothesis #1 was rejected for each of these relationships.

The correlations between the visual inference task scores and the sex variable were not found to be significant. The correlations between the auditory-haptic inference task scores and the variables sex, reasoning ability and perceptual speed ability were not found to be significant. Therefore, hypothesis #1 was accepted for each of these relationships. This information is

summarized in Table IV.

TABLE IV

CORRELATIONS BETWEEN INFERENCE SCORES AND SPECIFIED VARIABLES

Variable	N	Visual Task Inference Scores	N	Auditory-Haptic Inference Task Scores
Visual Inference Task	108	1.000		.479[b]
Auditory-Haptic Inference Task	67	.479[b]		1.000
Sex	108	.053	64	-.004
Age	108	.479[b]	64	.313[c]
Grade	108	.533[b]	64	.334[c]
General Intelligence	108	.564[b]	64	.351[d]
Verbal Ability	108	.403[b]	64	.334[c]
Spatial Relations Ability	108	.369[b]	64	.242[d]
Numerical Ability	108	.539[b]	64	.284[d]
Reasoning Ability	54[a]	.435[b]	40	.180
Perceptual Speed Ability	108	.208[d]	64	.144

[a]Reasoning ability measured for grades 4-6 only

[b]Significant at .001 level

[c]Significant at .01 level

[d]Significant at .05 level.

Conclusions: Hypothesis #1, dealing with correlations between the scores obtained for the two inference tasks and between each of these scores and the specified variables, was rejected with respect to the inference task scores. The hypothesis was also rejected with respect to these scores in their relationship with the variables age, general intelligence, spatial relations ability, and numerical ability for both series of inference tasks. It was rejected, also, with respect to the variables grade, verbal ability, reasoning ability, and perceptual speed ability for the visual inference task. Hypothesis #1 was accepted with respect to the sex variable for both the visual inference task and the auditory-haptic inference task and was also accepted with respect to the variables grade, verbal ability, reasoning ability and perceptual speed ability for the auditory-haptic inference task.

Hypothesis #2

There is no significant difference between boys and girls in:

(a) visual inference task score,

(b) auditory-haptic inference task score,

in each of the grades one through six.

The purpose of hypothesis #2 was to determine whether boys or girls have greater inference abilities with respect either to the visual inference task or to the auditory-haptic inference task. Scores relating to this hypothesis were analysed by means of a two-tailed "t" test carried out by the ANOV1Ø IBM 360/67 computer program. A list of the mean scores for the boys and girls in each grade is given in Table V, and a complete summary of the "t" values and probability levels

calculated in making the comparison between boys and girls is given in Table VI.

TABLE V

MEAN INFERENCE SCORES FOR BOYS AND GIRLS BY GRADE

Variable	Sex	One N	One Score	Two N	Two Score	Three N	Three Score	Four N	Four Score	Five N	Five Score	Six N	Six Score
Visual Inference Task	Boys	9	25.44	9	29.33	9	38.67	9	37.78	9	39.00	9	39.33
	Girls	9	14.67	9	28.44	9	31.44	9	42.11	9	37.00	9	43.00
Auditory-Haptic Inference Task	Boys			6	22.17	6	25.00	7	25.71	6	23.00	5	27.80
	Girls			6	22.16	6	23.17	7	26.86	8	24.00	7	24.57

TABLE VI

COMPARISONS OF BOYS AND GIRLS INFERENCE SCORES WITHIN EACH GRADE

Variable	Grade	S.Dev. Boys	S.Dev. Girls	Degrees of Freedom	T	Prob.
Visual Inference Score	One	12.74	7.14	16	2.214	.041[a]
	Two	15.48	11.00	16	.140	.890
	Three	9.81	13.56	16	1.295	.213
	Four	12.25	3.98	16	-1.010	.327
	Five	9.11	7.04	16	.521	.609
	Six	12.14	2.50	16	-.887	.388
Auditory-Haptic Inference	One	--	--	--	--	--
	Two	5.68	5.19	10	.053	.958
	Three	3.22	5.53	10	.702	.498
	Four	1.98	2.12	12	-1.044	.316
	Five	2.76	2.51	12	-.708	.492
	Six	5.45	5.06	10	1.056	.315

[a]significant at .05 level

(a) Visual Inference Task Score: Significant differences in scores with respect to this variable were found to exist between boys and girls in grade one only. The "t" value of 2.214 was significant at the 0.05 level. Therefore, hypothesis #2 was accepted for grade two, three, four, five, and six on the visual inference task variable but was rejected for grade one.

(b) Auditory-Haptic Inference Task Score: None of the "t" values calculated for each of the grades two to six on the auditory-haptic inference task scores yielded a probability which was significant at the 0.05 level or better. Therefore, hypothesis #2 was accepted for each of the grades two through six for the auditory-haptic inference task.

Conclusion: Hypothesis #2 may be rejected for grade one for the visual inference task. The mean visual inference score for the boys exceeded that of the girls in grade one. Therefore, it may be concluded that a significant difference exists between sexes in visual inference ability in grade one.

Hypothesis #3

There is no significant difference between grade levels in:

(a) visual inference task score,

(b) auditory-haptic inference task score

from grades one through six.

The purpose of this hypothesis was to determine if any improvement in the inference abilities of students (as measured by this study) may be detected from grades one through six. The data relating to this

hypothesis were tested by the Scheffé multiple comparison of means as calculated by the use of the ANOV15 IBM 360/67 computer program. The 0.10 level of significance was used as a basis for the acceptance or rejection of this hypothesis. Table VII gives the Scheffé probability matrices for the multiple comparison of each of the inference task score means for grades one through six.

1) Visual Inference Task: In six of a possible fifteen cases, the mean visual inference score was significantly different between the pairs of grades compared. The grade one mean score was not significantly different from the grade two mean score but it was significantly lower than the mean scores for each of the grades three, four, five and six. The grade two mean score was significantly lower than the mean scores of grades four and six. The grade three and five mean scores were significantly better than only the grade one mean score while the grade four and six mean scores were significantly better than the grade one and two mean scores only. Table VII summarizes this information.

2) Auditory-Haptic Inference Task: There was a progressive increase in the mean scores from grades two through six but the difference in mean scores between any two grades was not significant for any pair. See Table VII for this information.

Conclusion: Although significant differences were not found between each of the grades for the visual inference scores, enough significant differences existed to indicate a pattern of growth in inference ability with respect to the visual inference task. This growth pattern was most significant in grades one and two. See Table VII. Hypothesis #3, therefore, may be rejected with respect to visual

TABLE VII

SCHEFFÉ PROBABILITY MATRICES FOR EACH OF THE INFERENCE SCORES BY GRADE

Variable	Grade	One	Two	Three	Four	Five	Six
Visual Inference Task Score	One	1.000	.286	.004[a]	.000[a]	.000[a]	.000[a]
	Two	.286	1.000	.688	.088[a]	.252	.039[a]
	Three	.004[a]	.688	1.000	.857	.982	.697
	Four	.000[a]	.088[a]	.857	1.000	.997	.999
	Five	.000[a]	.252	.982	.997	1.000	.975
	Six	.000[a]	.039[a]	.697	.999	.975	1.000
Auditory-Haptic Inference Task Score	One	--	--	--	--	--	--
	Two	--	1.000	.791	.133	.893	.262
	Three	--	.791	1.000	.711	.999	.884
	Four	--	.133	.711	1.000	.592	.997
	Five	--	.893	.999	.592	1.000	.795
	Six	--	.262	.884	.997	.795	1.000

[a]indicates significance at the 0.10 level.

<u>inference scores for all comparisons between pairs of grades except between combinations of pairs represented by grades three, four, five and six.</u>

<u>Hypothesis #3 must be accepted with respect to the auditory-haptic inference scores as no significant differences were found between any grade pairs.</u>

<u>Hypothesis #4</u>

There is no significant difference between low, average and high I.Q. students in:

(a) visual inference task score,

(b) auditory-haptic inference task score,

in each of the grades one through six.

The purpose of this hypothesis was to determine if significant differences in inference ability as measured by this study exist between I.Q. groups within each grade. The data bearing on this hypothesis were tested by means of a Scheffé multiple comparison of means which was calculated by use of the ANOV15 IBM 360/67 computer program. The 0.10 level of significance was used as the basis for accepting or rejecting this hypothesis. Table VIII provides the mean inference scores for each I.Q. group in each grade and a summary of the probability levels derived from the Scheffé multiple comparison of means is found in Table IX.

TABLE VIII

MEAN INFERENCE SCORES FOR EACH I.Q. GROUP BY GRADE

Variable	I.Q. Group	Grade One N	Grade One Score	Two N	Two Score	Three N	Three Score	Four N	Four Score	Five N	Five Score	Six N	Six Score
Visual Task Score	High	4	24.75	7	39.14	9	42.33	9	43.22	6	39.50	8	44.62
	Average	5	24.60	5	23.40	5	29.60	4	43.00	8	37.88	6	42.33
	Low	9	15.44	6	21.50	4	25.50	5	31.60	4	36.00	4	32.50
Auditory-Haptic Task Score	High	-	--	6	25.00	5	24.60	7	26.43	5	24.40	5	28.20
	Average	-	--	2	21.50	4	24.50	3	27.00	7	23.14	3	25.67
	Low	-	--	4	18.50	3	22.67	4	25.50	2	23.00	4	23.25

1. Visual Inference Task Score: There were no significant differences found between the scores obtained by any pair of I.Q. groups at the grade one level. At the grade two level there was a significant difference between the scores obtained by the average I.Q. group and the high I.Q. group. Significant differences in scores with respect to this variable were found to exist between the high I.Q. group and the low I.Q. group for grades two, three, four and six. No significant differences between the scores of any of the groups were found in grade five. See Table IX for a complete presentation of probability levels.

2. Auditory-Haptic Inference Task Score: No significant differences in performance with respect to this variable were found to exist between any I.Q. groups for any of the grades two through six. See Table IX for this information.

Conclusion: Significant differences found in the scores for the visual inference task between I.Q. groups in each of the grades one through six were apparent in five of the eighteen comparisons made. Four of these significant score differences occurred in comparisons between low and high I.Q. groups. This was the most notable result to emerge. See Table IX. On the basis ot these results, hypothesis #3 was rejected only for the high-low I.Q. groupings for scores based upon the visual inference task.

No significant differences in performance on the auditory-haptic inference task scores between I.Q. groups in each of the grades two through six, were evident in this study. Therefore, hypothesis #4 was accepted on the basis of the scores obtained on the auditory-haptic

TABLE IX

SCHEFFÉ MULTIPLE COMPARISON OF MEANS OF I.Q. GROUPS BY GRADE [a]

Variable	I.Q. Groups Compared	Probability level by grade					
		One	Two	Three	Four	Five	Six
Visual Inference Score	High-Average	.999	.067[b]	.104	.998	.937	.860
	High-Low	.400	.029[b]	.041[b]	.056[b]	.812	.064[b]
	Average-Low	.360	.957	.829	.131	.935	.174
Auditory-Haptic Inference Score	High-Average	--	.664	.999	.928	.735	.808
	High-Low	--	.150	.860	.792	.827	.409
	Average-Low	--	.762	.883	.668	.997	.837

[a]indicating significant differences between I.Q. groups in performance of inference tasks

[b]indicates significance at the 0.10 level

inference task. See Table IX for this information.

Hypothesis #5

There is no significant interaction between grade level and I.Q. with respect to:

(a) visual inference task score,

(b) auditory-haptic inference task score.

The purpose of this hypothesis was to determine if I.Q. had any differential effect on each of the inference scores in the different grades. The data relating to this hypothesis were analysed by means of a 'test for additivity' calculated by utilization of the ANOV25 IBM 360/67 computer program.

The fact that the increase in inference score for both the visual and the auditory-haptic inference tasks was quite sharp and uniform from grades one to four is of importance here. For both inference tasks, the inference scores obtained for grade five decreased to levels below those obtained for grade four, an increase in magnitude of the scores being observable once again for grade six as shown in Figures 1 and 2.

1. Visual Inference Task Score: The mean visual inference score for each I.Q. group in each grade is presented in Table VIII. The test for additivity on this interaction yielded an F value of .982 which corresponds to a level of significance of .465. The criterion level of significance was taken to be 0.05. Thus, the interaction is not significant and hypothesis #5 could not be rejected with respect to this variable. Table X provides a summary of this information

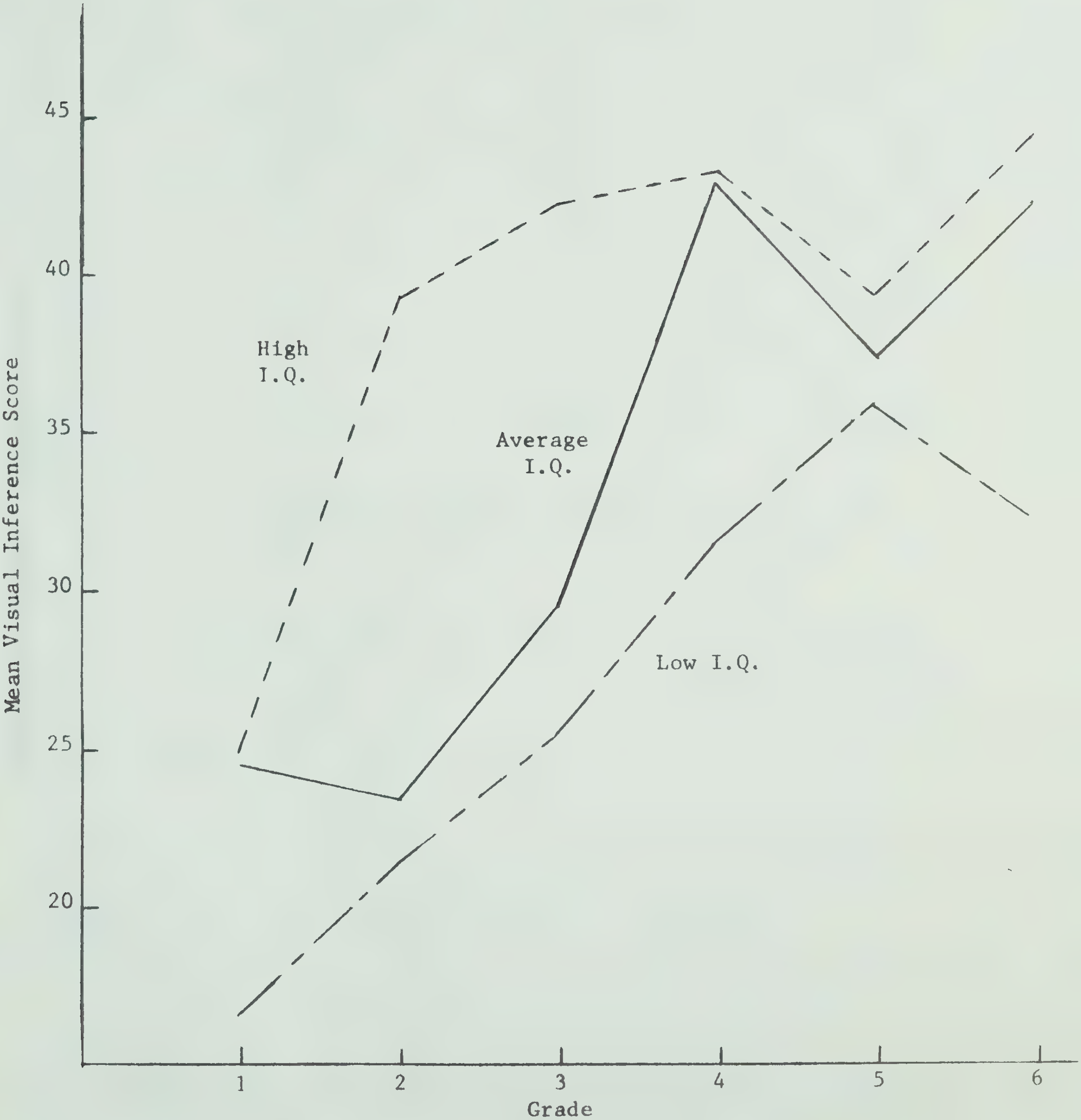

FIGURE 1

INTERACTION BETWEEN GRADE AND I.Q.
ON VISUAL INFERENCE SCORE CRITERION

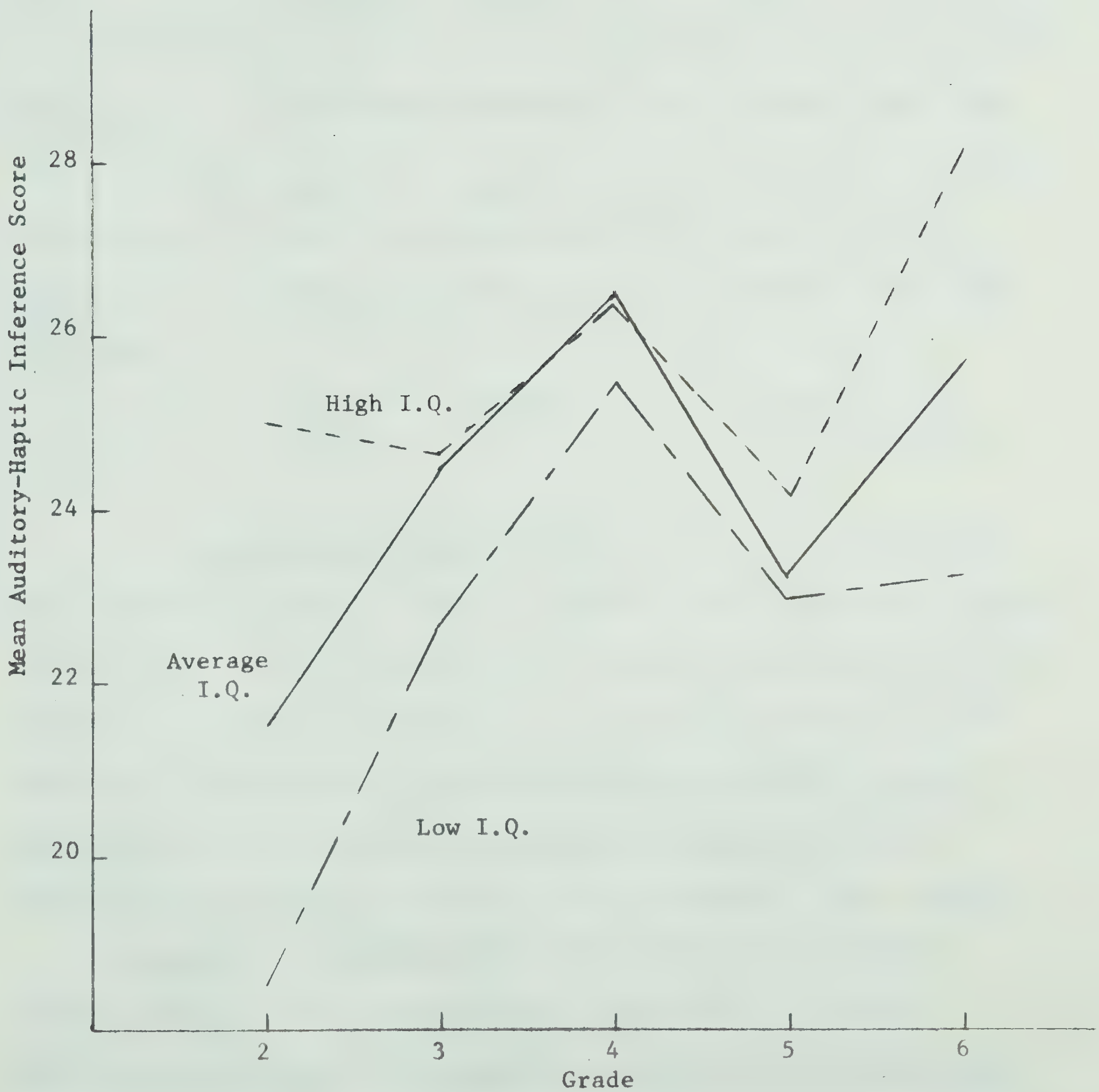

FIGURE 2

INTERACTION BETWEEN GRADE AND I.Q. ON AUDITORY-HAPTIC INFERENCE SCORE CRITERION

TABLE X

INTERACTION BETWEEN GRADE AND I.Q.
WITH RESPECT TO INFERENCE SCORES

Variable	Source of Variance	Sum of Squares	D.F.	Mean Squares	F	Prob.
Visual Inference Task	Interaction	858.063	10	85.806	.982	.465
	Error	7867.56	90	87.417		
Auditory-Haptic Inference Task	Interaction	60.102	8	7.513	.472	.870
	Error	779.367	49	15.906		

2. Auditory-Haptic Inference Task Score: The mean auditory-haptic inference scores for each I.Q. group in each grade were presented in Table VIII. The test for additivity for this variable resulted in an F value of .472 which corresponds to a level of significance of .870. Therefore, the interaction is not significant at the 0.05 level and hypothesis #5 was not rejected with respect to the auditory-haptic inference score variable. See Table X for a summary of these results.

Conclusion: Hypothesis #5, dealing with the interaction between grade and I.Q., was accepted on the basis of the scores obtained for both the visual inference task and auditory-haptic inference task variables. It was concluded, therefore, that no significant interaction occurred between high, average, and low I.Q. groups in grades one through six for the variables identified in this study.

Hypothesis #6

There is no significant interaction between grade level and sex with respect to:

(a) visual inference task score,

(b) auditory-haptic inference task score.

The purpose of hypothesis number six was to determine if sex has any differential effect on each of the criterion scores in different grades. The data upon which this hypothesis was based were analysed by means of the test for additivity calculated by means of the ANOV25 IBM 360/67 computer program. Figures 3 and 4 show the relationship between inference scores in each grade level and the sex variable.

1. Visual Inference Task Score: The mean visual inference scores for boys and girls in each grade were presented in Table V. The test for additivity on this variable yielded an F value of 1.469 which results in a level of significance of .207. Therefore, there is no significant interaction between sex and grade on the visual inference task score variable and hypothesis #6, with respect to this variable, was accepted. Table XI provides this information.

2. Auditory-Haptic Inference Task Score: The mean auditory-haptic inference scores for boys and girls in each grade are also presented in Table V. The test for additivity on this variable resulted in an F value of .669. A probability of .617 which is not significant at the 0.05 level, was yielded by this F value. Therefore, hypothesis #6, with respect to the auditory-haptic task score was accepted.

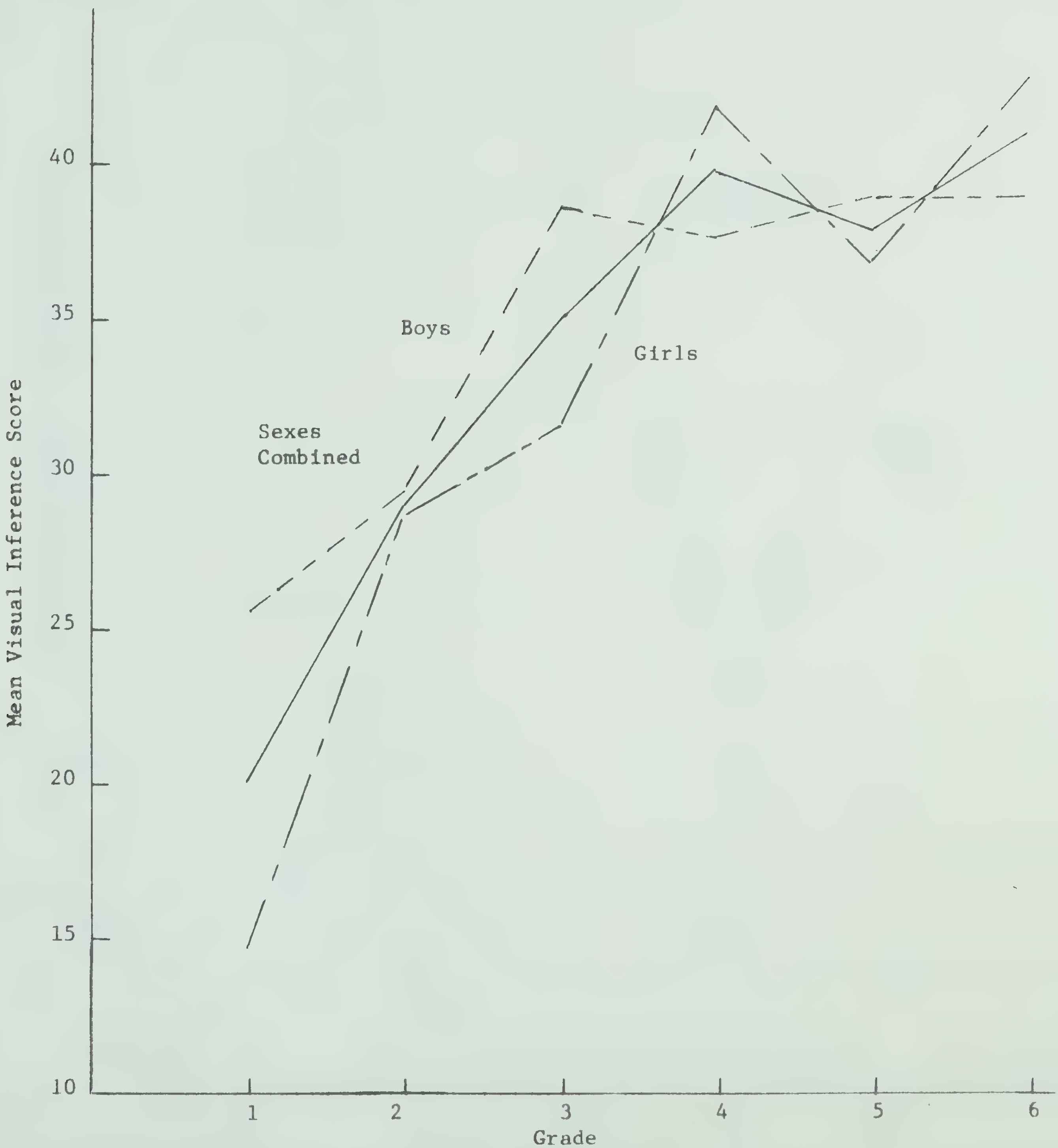

FIGURE 3

INTERACTION BETWEEN GRADE AND SEX ON
VISUAL INFERENCE SCORE CRITERION

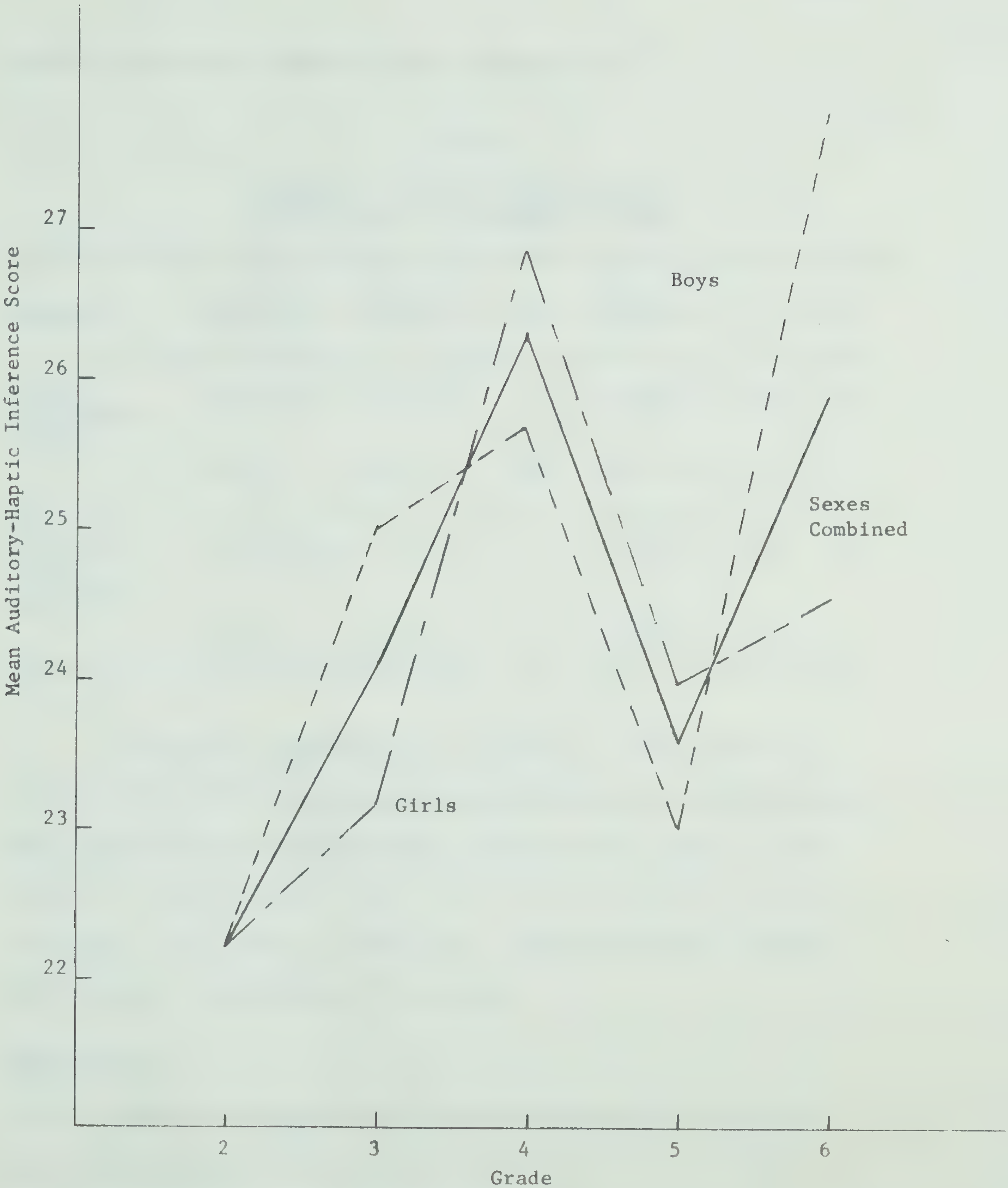

FIGURE 4

INTERACTION BETWEEN GRADE AND SEX ON AUDITORY-
HAPTIC INFERENCE SCORE CRITERION

Table XI contains a summary of this information.

TABLE XI

INTERACTION BETWEEN GRADE AND SEX
WITH RESPECT TO INFERENCE SCORES

Variable	Source of Variance	Sum of Squares	D.F.	Mean Squares	F	Prob.
Visual Inference Task	Interaction	799.375	5	159.875	1.469	.207
	Error	10447.2	96	108.826		
Auditory-Haptic Inference Task	Interaction	44.941	4	11.235	.669	.617
	Error	907.313	54	16.802		

Conclusion: Hypothesis #6, dealing with the interaction between grade and sex, was accepted on the basis of the analysis of both the visual and auditory-haptic inference task scores. It was therefore concluded that, on the basis of the criterion variables measured in this study, no significant interaction occurs between boys and girls in grades one through six.

Hypothesis #7

There is no significant interaction between I.Q. and sex with respect to:

(a) visual inference task score,

(b) auditory-haptic inference task score.

The purpose of this hypothesis was to determine if I.Q. has any differential effect on each of the criterion scores in the sample tested. The analysis used for this hypothesis was the test for additivity calculated by means of the ANOV25 IBM 360/67 computer program. Figures 5 and 6 show graphically the relationship between inference score, I.Q. and sex for both inference tasks.

1. Visual Inference Task Score: The mean visual inference scores for boys and girls in each I.Q. group are presented in Table XII. The test for additivity on the visual inference score variable yielded an F value of .535 which results in a level of significance of .587. Therefore, there is no significant interaction between sex and I.Q. with respect to the visual inference variable. Hypothesis #7, with respect to this variable, was accepted. Table XIII summarizes this information.

2. Auditory-Haptic Inference Task Score: The mean auditory-haptic inference scores for boys and girls in each I.Q. group are presented in Table XII. The test for additivity on the auditory-haptic inference score variable yielded an F value of .106 resulting in a probability level of .899. Thus, there is no significant interaction between sex and I.Q. with respect to the auditory-haptic inference variable. Hypothesis #7, with respect to this variable, was accepted. Table XIII contains this information.

Conclusion: Hypothesis #7, dealing with the interaction between I.Q. and sex, was accepted on the basis of the analysis of both the visual and auditory-haptic inference task scores. It was,

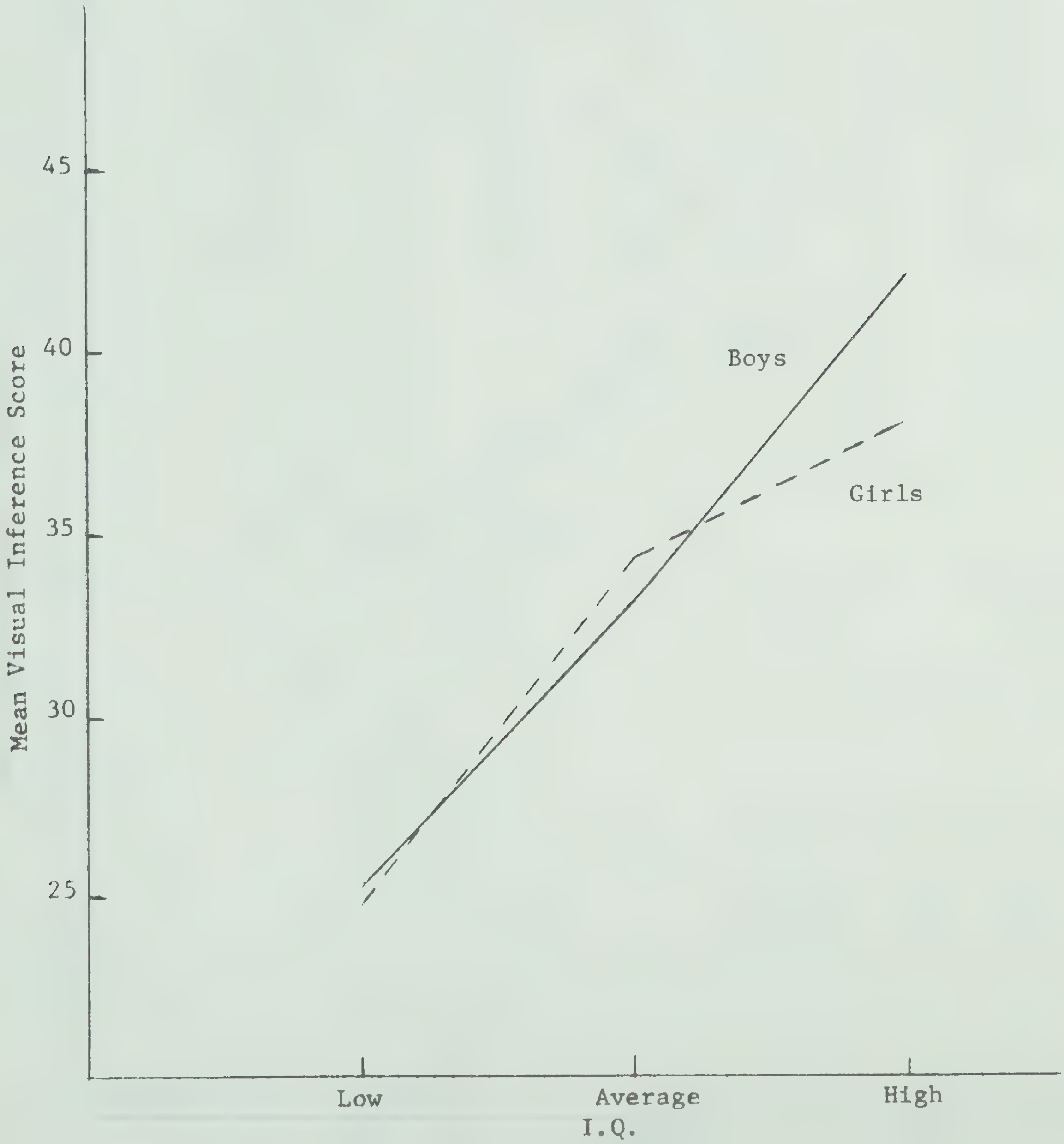

FIGURE 5

INTERACTION BETWEEN I.Q. AND SEX ON
VISUAL INFERENCE SCORE CRITERION

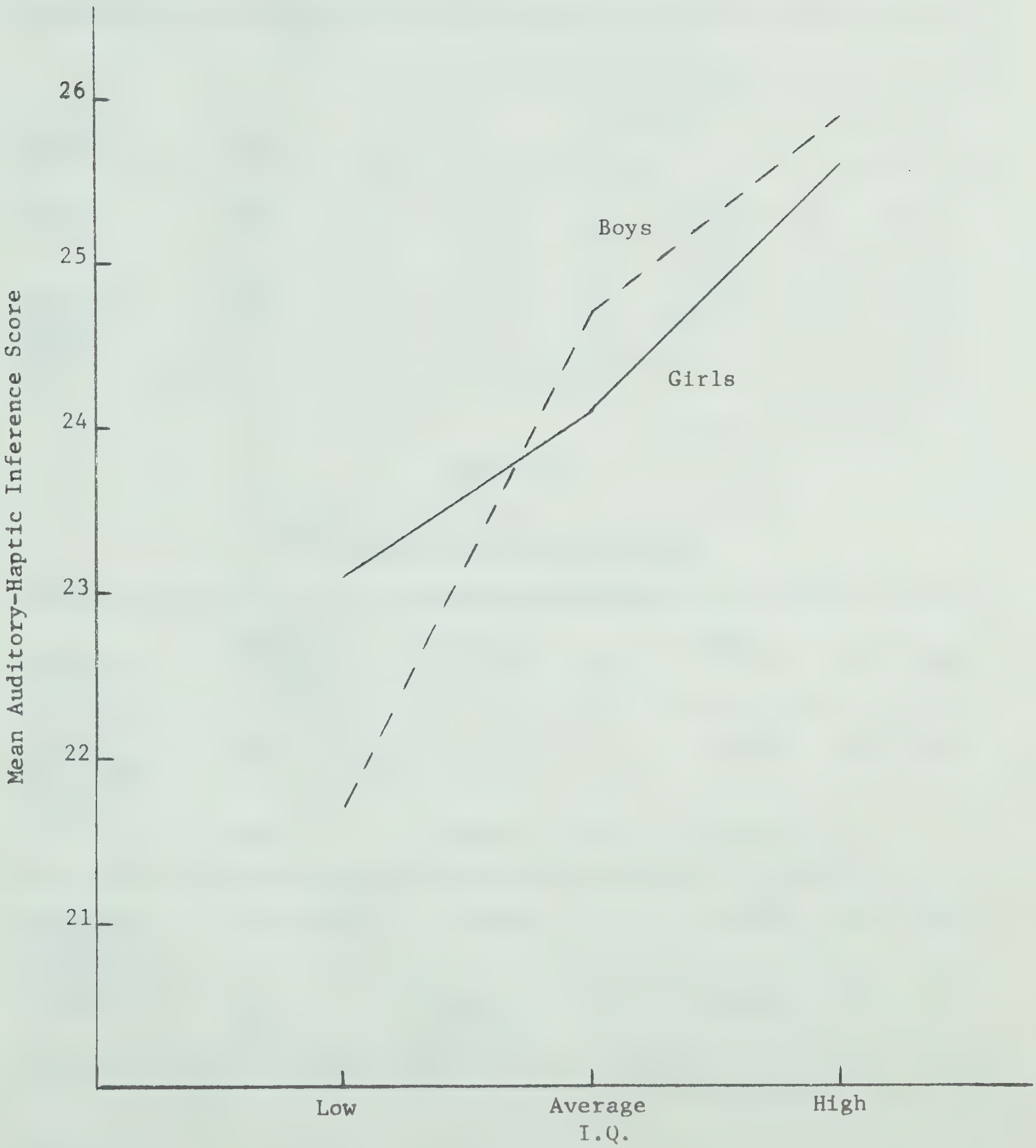

FIGURE 6

INTERACTION BETWEEN I.Q. AND SEX ON
AUDITORY-HAPTIC SCORE CRITERION

TABLE XII

MEAN INFERENCE SCORES FOR
EACH I.Q. GROUP BY SEX

		I. Q.					
		High		Average		Low	
Variable	Sex	N	Score	N	Score	N	Score
Visual Task	Boys	23	42.30	16	33.31	15	25.33
	Girls	20	38.20	17	34.35	17	24.82
Auditory -Haptic Task	Boys	14	25.86	6	24.67	10	23.10
	Girls	14	25.64	13	24.07	7	21.71

TABLE XIII

INTERACTION BETWEEN I.Q. AND SEX WITH
RESPECT TO INFERENCE SCORES

Variable	Source of Variance	Sum of Squares	D.F.	Mean Squares	F	Prob.
Visual Inference Task	Interaction	133.375	2	66.6875	.535	.587
	Error	12703.4	102	124.543		
Auditory-Haptic Inference Score	Interaction	3.55859	2	1.77930	.106	.899
	Error	977.523	58	16.8539		

therefore, concluded that on the basis of the criterion variables measured, no significant interaction occurs between I.Q. groups and boys and girls in grades one to six.

The significance and implication of these conclusions are discussed in Chapter 5.

DESCRIPTION OF PERFORMANCE

The average performance of the pupils in each grade for each of the scored patterns in the visual inference task is shown in Table XIV, the average performances of the pupils in each grade for each of the scored boxes and criteria in the auditory-haptic task being given in Table XV and Table XVI.

These tables indicate the following:

1. Visual Inference Task. Eight separate patterns of blocks or slopes or blocks and slopes were used in presenting this task to each child.

Scores on the first pattern, which consisted of one block in slots two and five, (see Figure 7) were fairly constant and of the same order of magnitude for all grades except grade one, which was somewhat lower in magnitude. The mean score on pattern one for grade one was 2.94 with the mean scores for grades two to six varying from 3.67 to 3.89 out of a possible total of 4.00. Thus, for grade two to six, patterns involving blocks only were identified with little difficulty.

TABLE XIV

MEAN VISUAL INFERENCE SCORES FOR EACH PATTERN BY GRADE

Pattern	Total Possible Score	Grade											
		One	%	Two	%	Three	%	Four	%	Five	%	Six	%
1	4.00	2.94	73.5	3.67	91.7	3.89	97.2	3.72	93.0	3.78	94.5	3.89	
2	4.00	2.40	60.0	3.22	80.4	3.50	87.5	3.50	87.5	3.78	94.5	3.83	
3	6.00	2.78	46.3	3.89	64.8	4.72	78.7	5.00	84.0	4.83	80.5	5.39	
4	2.00	.61	30.5	.78	39.0	1.50	75.0	1.67	83.5	1.44	72.0	1.67	
5	6.00	2.94	49.0	3.56	59.3	4.72	78.7	5.28	86.0	4.72	78.7	5.39	
6	6.00	3.00	50.0	4.11	68.5	4.50	75.0	5.11	85.1	5.17	86.3	5.44	
7	6.00	2.11	35.5	3.44	57.3	4.22	70.3	5.50	91.7	4.94	82.3	5.56	
8	12.00	3.28	27.3	6.22	51.8	8.00	66.7	10.12	84.4	9.44	78.7	10.00	

TABLE XV

MEAN AUDITORY-HAPTIC INFERENCE SCORES FOR EACH BOX BY GRADE

Pattern	Total Possible Score	Grade									
		Two	%	Three	%	Four	%	Five	%	Six	%
1	10	5.42	54.2	6.00	60.0	5.93	59.3	5.64	56.4	5.58	55.8
2	9	4.42	49.1	4.08	45.3	5.07	56.3	4.86	54.0	5.08	56.4
3	10	3.25	32.5	3.67	36.7	4.00	40.0	3.29	32.9	4.17	41.7
4	10	2.67	26.7	2.75	27.5	3.45	34.3	2.86	28.6	3.33	33.3
5	9	3.00	33.3	3.33	37.0	3.29	36.6	2.57	28.6	3.50	38.8
6	12	3.58	29.8	4.33	36.1	4.57	38.1	4.36	36.3	4.25	35.4

TABLE XVI

MEAN AUDITORY-HAPTIC INFERENCE SCORES
FOR EACH CRITERION BY GRADE

Criteria	Total Score Possible	Grade: Two	%	Three	%	Four	F	Five	%	Six	%
Label	6	1.25	21.0	.55	9.0	1.00	16.7	.45	7.5	.76	12.7
Movement	15	8.83	59.0	1.80	12.0	10.29	68.0	1.68	11.2	2.14	14.3
Weight	6	1.83	30.5	1.60	26.7	1.64	28.1	.99	16.5	1.71	28.5
Size	6	.16	2.7	.37	6.0	.28	4.7	.62	10.3	1.09	18.2
Shape	6	2.08	34.7	.76	12.7	3.14	52.3	.50	8.3	.95	16.0
Composition	6	4.00	67.7	1.26	21.0	4.71	78.5	.96	16.0	1.09	18.0
Sound	7	3.67	52.4	1.32	19.0	4.93	70.4	1.39	20.0	1.65	23.4
Feel	8	.50	6.3	1.50	18.8	.29	36.3	.48	6.0	.83	10.4

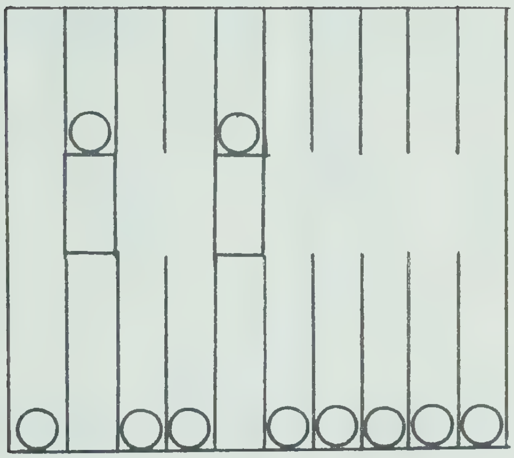

FIGURE 7

BLOCK AND BALL DISTRIBUTION
FOR PATTERN ONE

The mean scores for <u>pattern two</u> showed that a decrease in difficulty in performing the test was experienced by the students in progression from grade one through six. This pattern consisted of a right handed slope in slot three and a block in slot seven (See Figure 8). The introduction of a slope seems to have been responsible for a general depression in the mean scores for each grade for pattern two compared with that obtained for pattern one, the total possible score being the same for both patterns one and two.

<u>Pattern three</u> consisted of a right handed slope in slot one, followed by a block in slot four and another right handed slope in slot eight (See Figure 9).

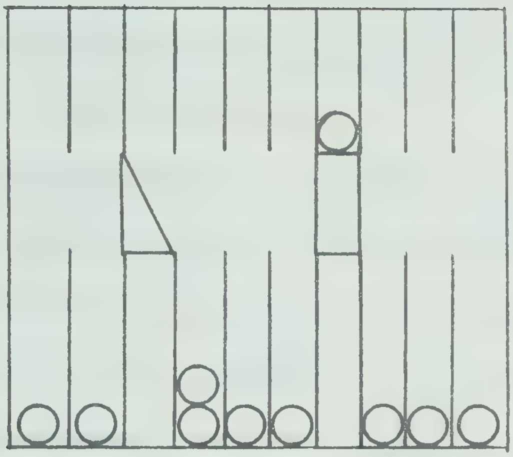

FIGURE 8

BLOCK, SLOPE AND BALL DISTRIBUTION
FOR PATTERN TWO

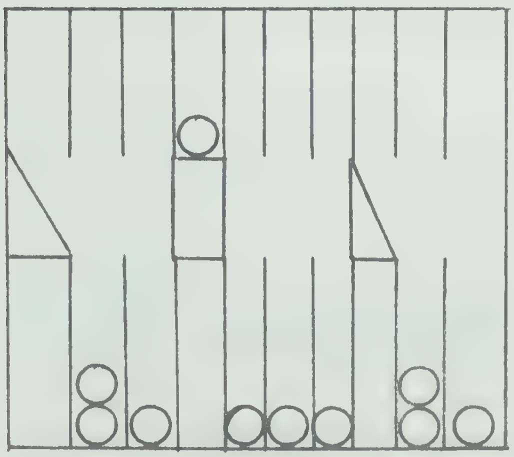

FIGURE 9

BLOCK, SLOPE AND BALL DISTRIBUTION
FOR PATTERN THREE

Once again, a continual improvement in scores from grade one through grade six was noted with the exception of grade five which scored slightly lower than grade four.

The <u>fourth pattern</u> appeared to present the most difficulty to the students. It consisted solely of a left handed slope in slot number four (See Figure 10). Apparently, the children had problems in adjusting their thinking to accommodate a left handed slope even though they were told at the outset that there would be other "kinds" of slopes. In terms of the total possible percentage scores for this pattern the means ranged from 30.5% for grade one to 83.5% for grades four and six.

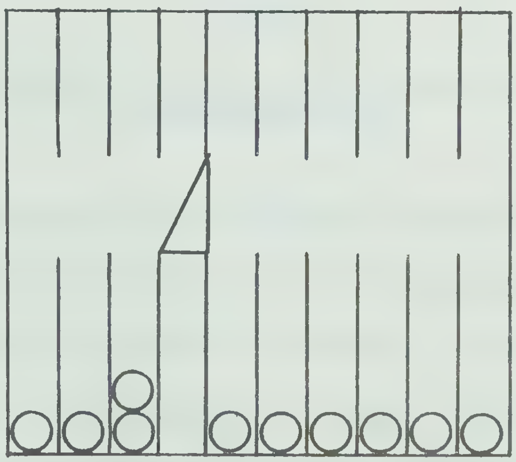

FIGURE 10

SLOPE AND BALL DISTRIBUTION
FOR PATTERN FOUR

Pattern five consisted of a left handed slope in slot two with a block in slot five and a left handed slope in slot eight (See Figure 11).

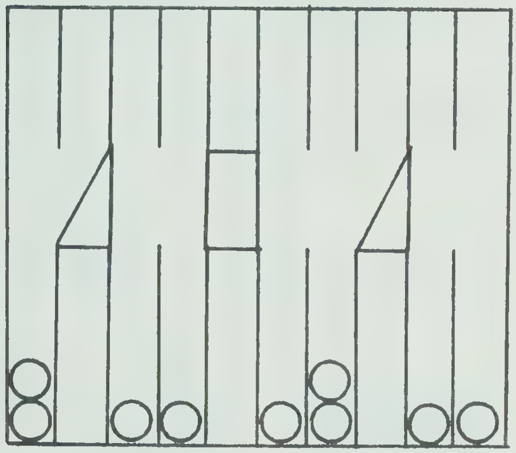

FIGURE 11

BLOCK, SLOPE AND BALL DISTRIBUTION
FOR PATTERN FIVE

Each grade mean score for pattern five was approximately the same as that obtained for pattern three. There was a continual increase in score from grade one through to grade six, again with the exception of grade five, which scored lower than grade four.

Pattern six consisted of combined left and right handed slopes in slots two and three, with a block in slot six (See Figure 12). The mean scores derived from this pattern showed a progressive increase in magnitude ranging from 3.00 for grade one to 5.44 for grade six, the total possible being 6.00. It is to be noted that the mean scores for each grade for pattern six are greater than those for pattern five, indicating that the children may have benefited from their

experience with patterns four and five. At this stage of the test cycle it appeared that the majority of children had few problems in identifying the presence of a block.

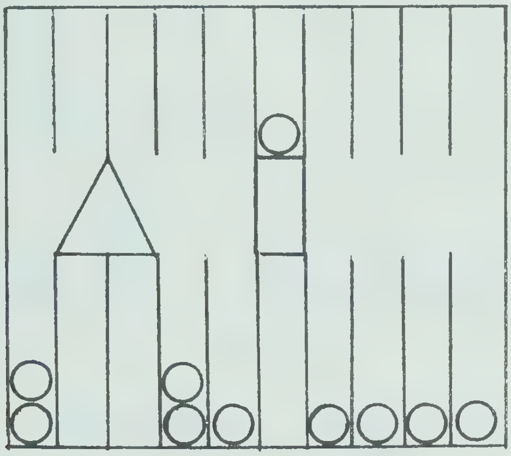

FIGURE 12

BLOCK, SLOPE AND BALL DISTRIBUTION
FOR PATTERN SIX

In pattern seven a right handed slope was placed in slot two with a left handed slope in slot four and a right handed slope in slot five (See Figure 13).

This particular configuration appeared to cause somewhat more difficulty than pattern six. Once again, this pattern proved to be much more difficult for the early grades than for grades four, five and six.

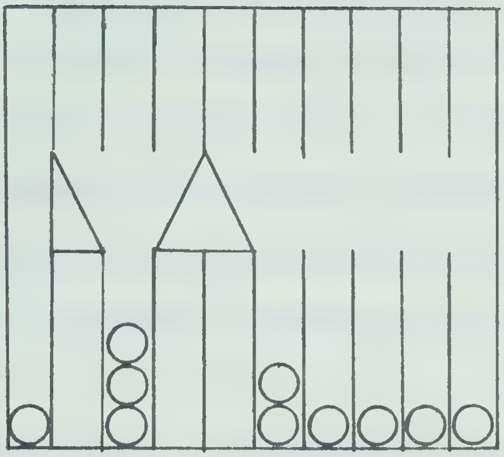

FIGURE 13

SLOPE AND BALL DISTRIBUTION
FOR PATTERN SEVEN

The eighth pattern was the most complicated. A double-slot left handed slope occupied slots two and three, a right handed slope was located in slot four, a left handed slope in slot six and a right handed slope in slot seven. Finally, another right handed slope was placed in slot nine (See Figure 14). Grades one, two and three

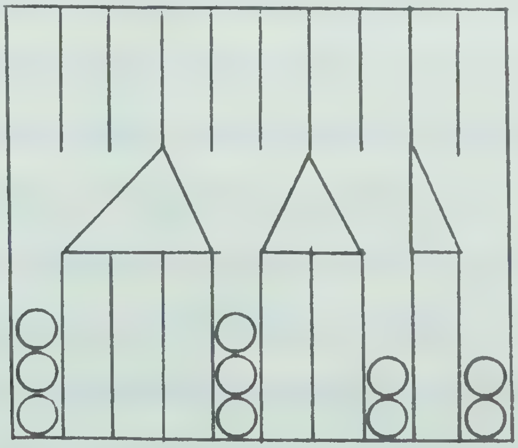

FIGURE 14

SLOPE AND BALL DISTRIBUTION
FOR PATTERN EIGHT

appeared to have more difficulty with this pattern than did grades four, five, and six. The mean scores derived for grades one, two, and three varied from 3.28 to 8.00 whereas the values varied from 9.44 to 10.12 for grades four, five and six, the total score possible being 12.00. Direct observation of the younger children as they worked on this pattern of distribution of balls seemed to indicate that they had great difficulty in relating and comparing the many slopes giving rise to the pattern.

For all of the patterns the students in grades four, five, and six appeared to have few difficulties as their mean raw scores were consistently relatively high. This could mean that students at this level have few problems with drawing inferences from observed data, while those at the lower level are still at the stage where this ability is developing. This information is summarized in Table XIV.

2. Auditory-Haptic Inference Task. The raw scores obtained for the six boxed objects indicate a progressive increase in score from grade two through six. Few variations from this trend were observed most of them occurring at the grade five level where the scores obtained for each boxed object were lower than those obtained for the same objects by grade four students (See Table XV).

The apparent difficulty level of the task associated with each box at each grade level is of some interest. The first box, containing a rubber ball, appeared to present the easiest task for all six grades. The second box, containing a weighted, rectangular, cardboard prism, afforded the second easiest task with respect to the drawing

of inference from observation from the point of view of the children. Box three, containing an aluminum rod about 1/2" in diameter and six inches long, generally presented greater difficulty than boxes one or two. The contents of boxes four and five appeared to present the most difficulty in interpretation for all six grades. Box four contained a circular disc made from a six inch roll of masking tape, and box five contained a weighted plastic pyramid with a two inch square base and a height of two and one-half inches. The mean scores obtained for the disc (Box 4) ranged from 2.67 for grade two to 3.45 for grade four; the total possible being 10.00. The mean scores for the pyramid (Box 5) varied from 2.57 for grade five out of a total possible of 9.00, to 3.50 for grade six with the other three grades having scores between 2.57 and 3.50. The sixth box, containing a balloon filled with mercury was found to present less difficulty to the students than boxes four and five. Table XV summarizes this information.

An analysis of the criteria used by the different grades in forming their inferences about the objects in the boxes is quite revealing. See Table XVI.

The "label" criterion appeared to be used more frequently by grade two than by any other grade. A mean score of 1.25 for grade two out of a possible total score of 6.00 for this criterion for all boxes combined could be compared with mean scores of .55, 1.00, .45, and .76 for grades three to six respectively.

The "movement" criterion was identified considerably more frequently by grades two and four than by the other grades. The grade two

mean score of 8.83 and the grade four mean of 10.29, out of a possible maximum of 15.00, are to be compared with the next closest mean score of 2.14 obtained by grade six.

The "shape" criterion much as in the case of the "movement" criterion was again chosen more frequently by grades two and four than by the other grades. Mean scores were 2.08 and 3.14 for grades two and four, out of a possible total of 6.00.

The "composition" criterion and the "sound" criterion showed the same kind of frequency pattern as did the "movement" and "shape" criteria. In both cases grade two and four students scored considerably higher than the students from grades three, five and six. See Table XVI.

The "weight" criterion was selected by students from each grade with about the same frequency. The mean scores on the "weight" criterion varied from a low of 0.99 for grade five to a high of 1.83 for grade two. The total possible was 6.00.

The "size" criterion was not chosen very frequently by students from any grade although students from the upper grades showed a fairly distinct preference for this criterion compared to children in the lower grades. The mean scores, out of a possible of 6.00, were 0.62 and 1.09 respectively for grades five and six while the mean scores for grades two, three and four were 0.16, 0.37 and 0.28 respectively.

Mean scores on the "feel" criterion were all quite low, with no real distinction being possible among grades other than perhaps in the case of the grade five students who achieved a mean score of 1.50 out of a possible total of 8.00. This is to be compared with the next

highest mean score of 0.83 obtained by grade six.

It should be noted that, on a percentage and ranking basis, the total sample achieved the highest scores on the following four criteria: sound, composition, weight and movement in that order. These four criteria, however, happen to be those for which the investigator chose to give a prompt if the student did not consider them in his response and the scores noted above should be viewed with this in mind. This information is summarized in Appendix G.

SUMMARY OF RESULTS

Hypothesis #1 examined the relationships between visual and auditory-haptic inference scores and the relationships existing between each inference score and other variables. A significant relationship was found to exist between the scores obtained for the two inference tasks. In addition, significant relationships were found to occur between each inference task and age, general intelligence, spatial relations ability and numerical ability. Significant relationships were also found between visual inference score and grade, verbal ability, reasoning ability and perceptual speed ability.

Hypothesis #2 which compared boys scores with girls scores in each of the grades one through six showed a significant difference between sexes only in the case of grade one for the visual inference task. In this instance the performance of the boys was superior to that of the girls.

Hypothesis #3 compared the inference scores obtained by each

[illegible]

[illegible]

[illegible]

[illegible]

grade with the inference scores for each of the other grades. A significant growth pattern was apparent through the first three grades for the visual inference task. No such significant pattern was found for the auditory-haptic task although the score means did increase through the grades.

Hypothesis #4 compared the scores obtained for each task by each of the I.Q. groups in each of the grades one through six. Significant differences were found between the high and low I.Q. groups for the visual inference score for grades two, three, four and six. Few significant differences were found between the high I.Q. and average I.Q. groups and between the average I.Q. and low I.Q. groups for the visual inference task. No significant differences were found between any pair of I.Q. groups for the auditory-haptic inference task.

Hypothesis #5 examined the possibility of interaction between the variables of I.Q. and grade level. It was found that no significant interaction existed with respect to the visual and auditory-haptic inference scores.

Hypothesis #6 revealed the absence of significant interaction between grade level and sex with respect to the two criterion variables.

Hypothesis #7 like #5 and #6 did not reveal the presence of significant interaction between I.Q. and sex for the visual and auditory-haptic inference tasks.

CHAPTER 5

SUMMARY, CONCLUSIONS, IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

SUMMARY

The main purpose of this study was to measure the inference abilities of children in grades one through six. An examination of the development of these abilities may be useful in determining what, if any, significant predictors of inference ability are available. A comparison of the grades with respect to each inference task was carried out as well as a study of the difficulties students encountered in performing inference tasks.

The study was carried out using a sample of one hundred and eight elementary school students, thirty-six from each of the Edmonton Public, Edmonton Separate and County of Strathcona school systems. The sample for the visual inference task consisted of eighteen randomly selected students from each of the grades one through six. Sixty-four students in grades two through six from the above sample also participated in the testing associated with the auditory-haptic inference task.

The I.Q. level for each child was assigned on the basis of his I.Q. score on the S.R.A. Primary Mental Abilities Test administered just prior to the investigation. The five subtests which are stated to measure five primary mental abilities within this particular measure of general intelligence were used in order to determine which mental

abilities, as defined by the test, contributed most to the inference process.

Each student was tested individually for inference ability by the investigator in a private room in the school which the child attended. For the visual inference task each child was presented with eight patterns of <u>blocks</u> or <u>slopes</u> or of blocks <u>and</u> slopes in an "inference machine". They were then required to make inferences about the block and/or slope distribution based upon the distribution pattern observed when balls were rolled through the "inference machine". The students were scored on the basis of the inferences drawn from observation of each pattern. For the auditory-haptic inference task each child was presented with seven closed aluminum boxes, six of them containing an object. The children were allowed to manipulate each box as much as they wished and, based on this manipulation, they were required to infer as much as possible about the nature of the object in each of the boxes, which they were not allowed to open. The possible responses were classified according to eight basic but comprehensive criteria. Student scores for each of the tasks were determined on the basis of their comments regarding the nature of the object in the box. 'Unacceptable' criteria, e.g., color, were not given a score by the investigator as this property could not be observed by the student. See data sheet in Appendix E.

The total data obtained from each inference task were subjected to an analysis of variance calculated by means of the ANOV1Ø, 15, and 25 IBM 360/67 computer programs as well as Pearson Product Moment

correlations calculated by the DESTØ5 IBM 360/67 computer program. All programs were provided by the Division of Educational Research Services of The University of Alberta.

CONCLUSIONS

The specific conclusions relating to each hypothesis are found in Chapter 4. On the basis of this information the following general conclusions were formulated:

1. A significant relationship exists between an elementary school child's ability to infer from a visual observation and his ability to infer from an auditory-haptic observation.

2. A student's potential success at being able to infer can be predicted, in part, by knowledge of his age, and on the basis of a knowledge of general intelligence, spatial relations ability and numerical ability as determined by means of the S.R.A. Primary Mental Abilities Test.

3. Knowledge of an individual's verbal ability or reasoning ability, as determined by means of the indicated S.R.A. test, were not predictors of the ability to infer on the basis of auditory-haptic observations. However, both verbal ability and reasoning ability together with grade level served as predictors of the ability to infer on the basis of visual observation.

4. The sex of an elementary school student did not influence his or her performance on the inference tasks other than in the case of the visual inference task at the grade one level, where boys did

appreciably better than the girls. Sample bias probably contributed to this isolated case of a sex-based difference.

5. Significant differences on performance of the visual inference task occurred between grade one and the other four grades with a significant difference also noted between grade two and grades four and six. There did not appear to be any significant differences between any of the grades on the basis of the scores obtained on the auditory-haptic inference task.

6. With respect to I.Q., the high I.Q. group obtained higher scores on the inference tasks than the average I.Q. group, which in turn scored higher than the low I.Q. group, although none of these differences were significant for the auditory-haptic inference task. Significant differences in performance among I.Q. groups were found to occur most frequently between the high I.Q. groups and the low I.Q. groups for the visual inference task. There were few significant differences between the average I.Q. group and either the high or low I.Q. groups.

7. The most significant result from this study would appear to be that emerging from hypothesis #3. A significant improvement in performance on the visual inference task was found to take place from grade one to grade two, with a continued but less significant rate of improvement occurring in grades three through six. The occurrence of a rapid increase in score from grade one to grade four for the visual inference task with a less rapid increase thereafter, tends to support the suggestions of Piaget and perhaps those of Gagné with respect to

the existence of developmental growth stages in the ability to handle tasks, even though the results obtained in this study are, at this juncture, of a somewhat tentative nature.

8. The lack of any significant performance differences between any two grades on the auditory-haptic inference task was also a matter of some interest. From the data collected it would appear that the younger children show a preference for the use of criteria such as label, movement and shape, whereas older children prefer to use size and weight criteria. However on the basis of overall scores such variations in preference tended to cancel one another out and the resultant effect was one of an absence of significant differences in performance between grades, although such differences on the bases indicated may be looked for.

IMPLICATIONS FOR TEACHING AND EVALUATION

The following implications may be drawn from this study:

1. The mean inference scores determined during the course of this study for each of the grades one through six for the visual and for the auditory-haptic inference task should prove helpful in comparing and evaluating the inference ability of other students on the basis of similar inference tasks.

2. The mean scores by grade for each inference task may be useful in setting standards of performance for those parts of the process oriented elementary science instructional sequence which involve inference.

3. The study indicates that inference related activities and experiences should be part of the grade one through six science program as no specific peak in ability with respect to this process was reached at or before the grade six level. Although there were indications of a reduction of inference ability at the grade five level this reduction was probably due to sampling bias.

4. The generally low scores on the auditory-haptic task imply that most elementary students should have experiences which enhance those powers of observation which have a basis in the auditory and haptic modes.

5. Special kinds of programs for the development of inference skills would appear to be needed for those students with a low I.Q., especially at the grade one and two level, where the discrepancy between the low I.Q. group and the high I.Q. group was the most pronounced.

6. Boys and girls appear to have the same basic inference abilities, thus presenting an area in which both sexes may be expected to perform equally well in tasks involving the drawing of inference from observation.

7. The use of tasks similar to those used in this study could serve as diagnostic tools for assessing the inference abilities of students in grades one through six. The tasks could then be used periodically to determine a student's growth in the inferring process.

SUGGESTIONS FOR FURTHER RESEARCH

This study showed a rather considerable increase in visual

inference score for the first four grades, a more gradual increase then being noted over the last two grades. Further research might be profitably undertaken to determine whether this levelling off was due to some intrinsic factor associated with inference ability tasks employed in this investigation, to the nature of the particular task used, or perhaps to the nature of the sample used in this study.

The nature, distribution and sequence of presentation of the blocks and slopes may well have a significant influence upon the nature of the results obtained from tasks similar to those employed in this study, and this area warrants further investigation.

In addition the nature and order of presentation of the boxed objects, as well as the significance of the size of the boxes and objects, is another area to be considered for further research with regard to the auditory-haptic task.

In this study it was found that auditory-haptic inference in the early elementary grades is based on criteria which are different from those employed in the later elementary grades. Additional research into the auditory-haptic inference abilities of elementary school students may be furthered by determining additional and more specific criteria which may be used at particular grade levels.

The effect of prompting upon some of the results obtained from this study as well as the significance of the criteria employed during prompting require further investigation in order to ascertain the overall influence of these factors.

Further studies would be useful in determining the grade levels

over which significant development of inference ability continues. This knowledge would be useful in the formulation of a coherent and sequential process based curriculum.

As indicated, the grade five inference scores in both inference tasks were generally lower than the grade four scores for each of the inference tasks. A more detailed study of this finding involving administration of the inference tasks to a different and/or more extensive sample may yield information that would explain this somewhat anomalous outcome.

In this study, the visual and the auditory-haptic modalities were the channels of sensory input. Further research using other modalities such as smell or taste, might be useful in determining inference abilities of elementary school students.

The results in this study include the average inference scores for students who have been on the new science curriculum for a maximum of four years. A similar study might be conducted at a later date to determine whether increased exposure to the new science program has had any significant influence on the development of the inference abilities of students.

A further possible area of research and development could involve the formulation of a series of specific and general exercises which would enable the student to build upon what might be termed his intrinsic ability to carry out tasks involving the drawing of inferences from observation. In addition a great deal of effort will be required to integrate the significant results of process studies into

some form of feasible science program. This task will include the development of simple and effective testing techniques and devices which provide a maximum amount of information with respect to a particular child's process development, yet may also be used for testing children in groups.

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APPENDIX A

PROCESS SKILLS

APPENDIX A

Process Skills (Methods of Inquiry)
(Curriculum Guide, 1969, pp. 7-9)

PROCESS	DESCRIPTION OF BEHAVIOR
Basic Processes	
Observing	The desired pupil behavior is increasing competence in using not only his sense of sight but also his other senses of hearing, touch, smell and taste.
Classifying	The desired pupil behavior is increasing competence in grouping articles, objects and ideas on the basis of some observable property or properties.
Quantifying	The desired pupil behavior is increasing competence in measuring length, weight, area, volume, and rate of change of the physical world.
Communicating	The desired pupil behavior is increasing competence in describing an experiment so that an individual who has not seen it can carry it out.
Inferring	The desired pupil behavior is increasing competence in drawing more than one inference from a set of data, demonstrating that inference can be tested by further observation, and demonstrating that an inference can be tested by applying known tests to the properties of objects. Pupils should indicate that they are able to distinguish between observations and inferences.
Predicting	The desired pupil behavior is increasing competence in conducting experiments to test predictions of relationships between two measurable quantities.

Integrated Processes

Formulating Hypotheses	The desired pupil behavior involves developing increasing competence in stating a hypothesis regarding causes of a phenomenon or the relationship between two variables. A hypothesis tells how to observe an expected outcome of an experiment.
Making Operational Definitions	The pupil should demonstrate increasing competence in stating the minimum things to do or look for in order to identify the subject being defined.
Controlling and Manipulating Variables	The desired pupil behavior is increasing competence in arranging conditions so as to be able to deliberately control and manipulate objects or conditions in an experiment.
Interpreting Data	The desired pupil behavior is increasing competence in getting the most out of data without over-simplifying, drawing conclusions supported by the data, and considering alternative explanations.
Formulating Models	The desired pupil behavior is increasing competence in building both physical and mental models to account for phenomena.
Experimenting	The desired pupil behavior is increasing competence in planning, conduction and communicating experiments in which the problem is clarified, hypotheses are stated, observations are made, and data is interpreted. This process depends upon the pupil being able to use all of the other processes.

APPENDIX B

PROCEDURAL INSTRUCTIONS FOR
VISUAL INFERENCE TASK

PROCEDURAL INSTRUCTIONS FOR VISUAL INFERENCE TASK

Hello _____________. You remember I said I would be back to meet with you by yourself.

Today we are going to work with this little machine. It is a wooden box with a glass bottom. Notice that there is a slope to the glass. There are ten slots in the box. Each slot is separated by a strip of wood except for the middle of each slot. I will use these steel balls to roll in each slot like this. Notice how they roll straight through each slot. This lid flips over and covers the centre part of each slot like this.

Now I will put our machine up on the overhead projector. The picture you see on the wall is just like looking at the machine. See the ten slots. Watch as I put a ball into each slot. Notice the black section across the middle where the lid is. (Lift up lid). Each time the balls will all go straight through the slots unless I put something in here to make them do something other than go straight through.

The first kind of thing I will put in is called a block. I won't show you a block but I will show you what a block does. I will put a block in slot three. Watch closely as I begin dropping balls in slot one. Number one, number two; (now remember there is a block in slot three), number three, number four, number five and so on.

Did you see what the block did in slot three? Good. Now you must remember what a block does.

The second kind of thing I will put in is called a slope. Again, I won't show you a slope, but I will show you what a slope does. I will put a slope in slot three. Watch closely as I begin dropping balls in slot one. Number one, number two (now remember there is a slope in slot three) number three, number four, number five, number six and so on. Did you see what the slope did in slot three? Good.

Now let's look at your answer sheets. Notice that each box looks like a small copy of what is on the wall. For each box that you have on your answer sheet I will set up a pattern in the machine using blocks and slopes. For example, if you think I have put a block in slot nine you will put a B in the little square at the bottom of slot nine. If you think I have put a slope in slot nine you will put an S in the square at the bottom of slot nine. After you have indicated where the slopes or blocks are I want you to draw them the way you think they look in the middle part of the slot. Do not put an S or a B if you do not think that either a slope or a block is in a slot. You should watch me drop all ten balls before you begin to fill in the answers.

Are there any questions?

APPENDIX C

DATA SHEET FOR VISUAL INFERENCE TASK

NAME__________ SCHOOL__________ GRADE______ AGE______

1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10

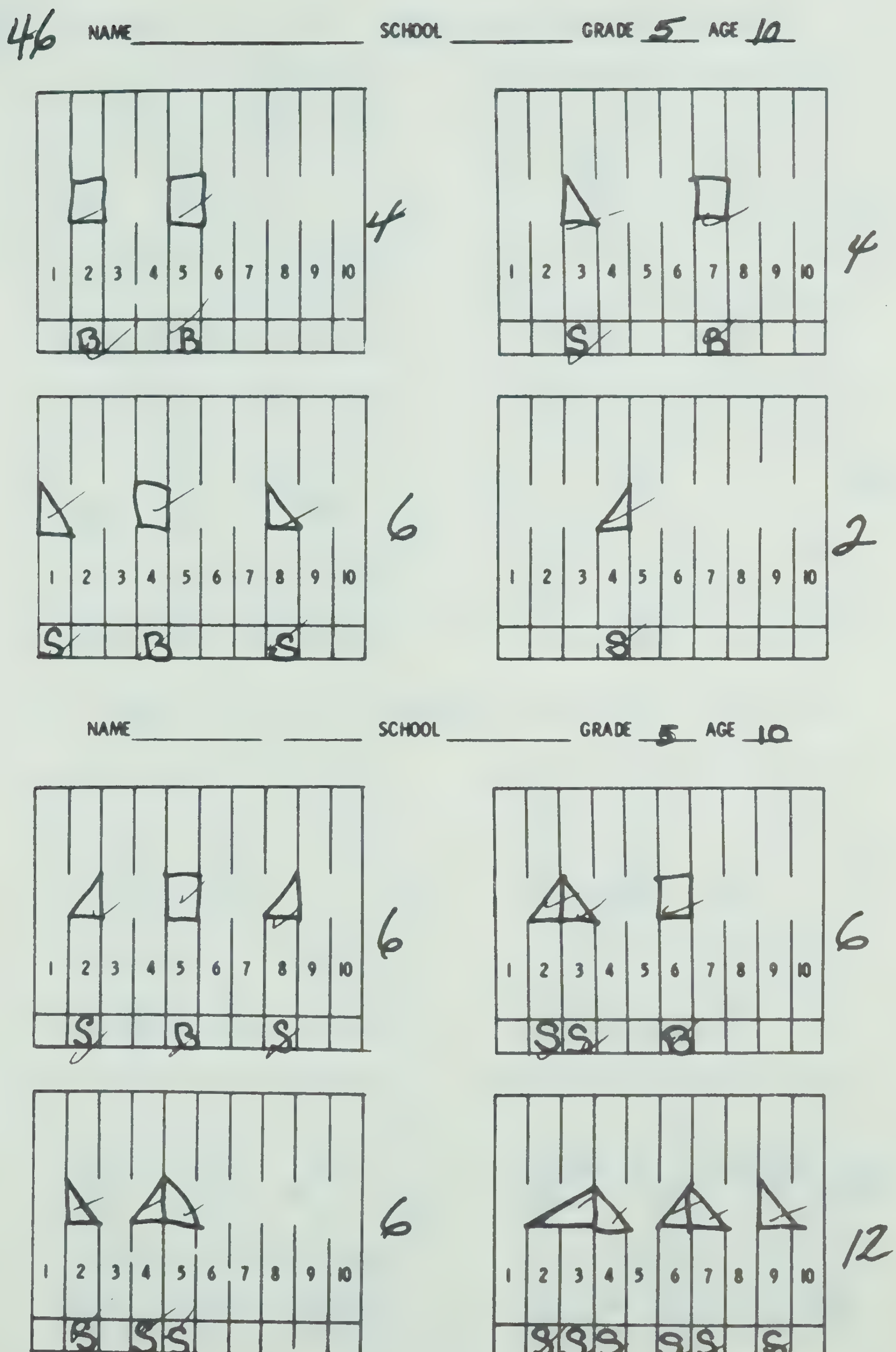
1	2	3	4	5	6	7	8	9	10

(2/3 of natural size)

VISUAL INFERENCE TASK DATA SHEET

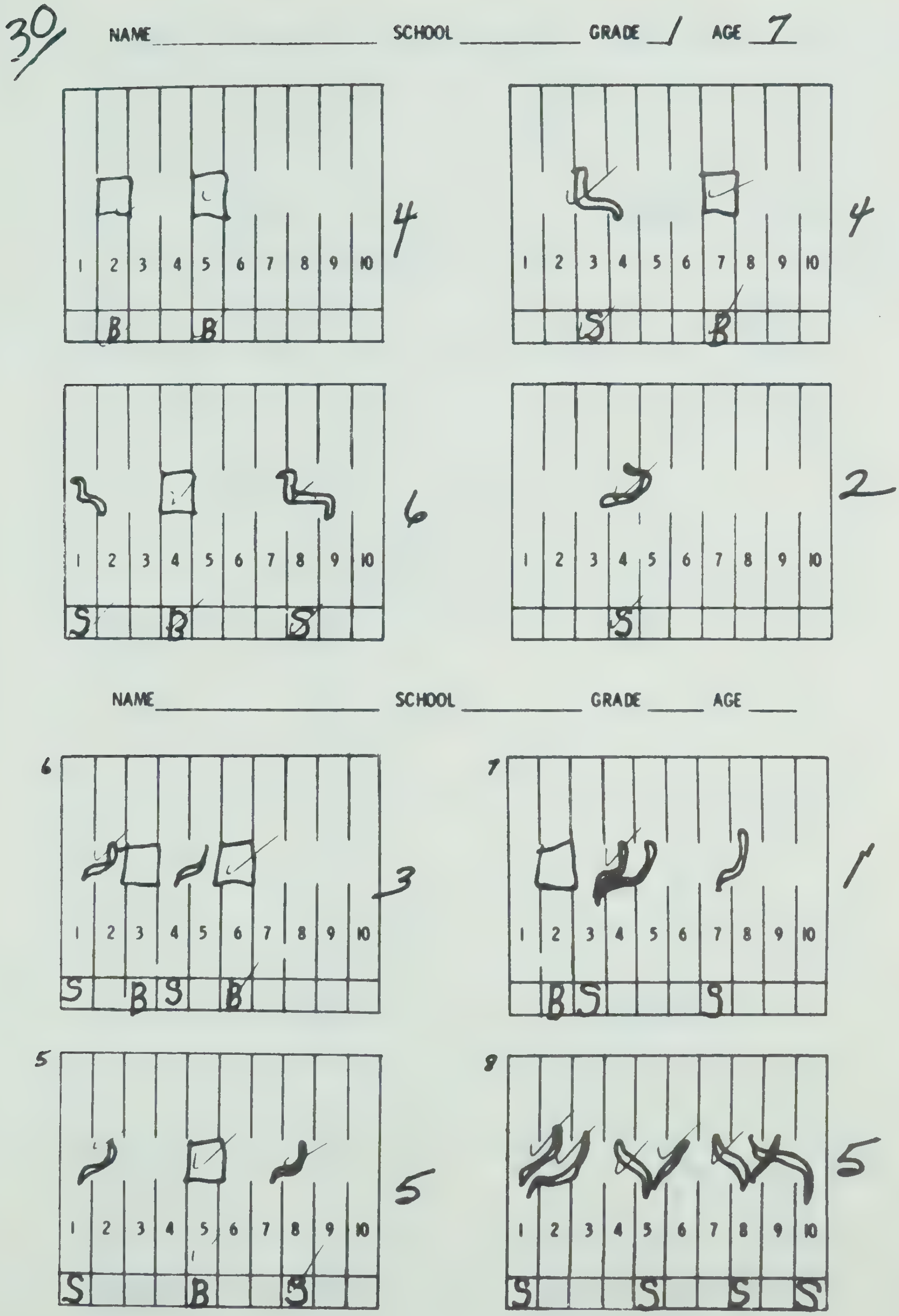
APPENDIX D

COMPLETED DATA SHEETS FOR
VISUAL INFERENCE TASK



(1/2 of natural size)

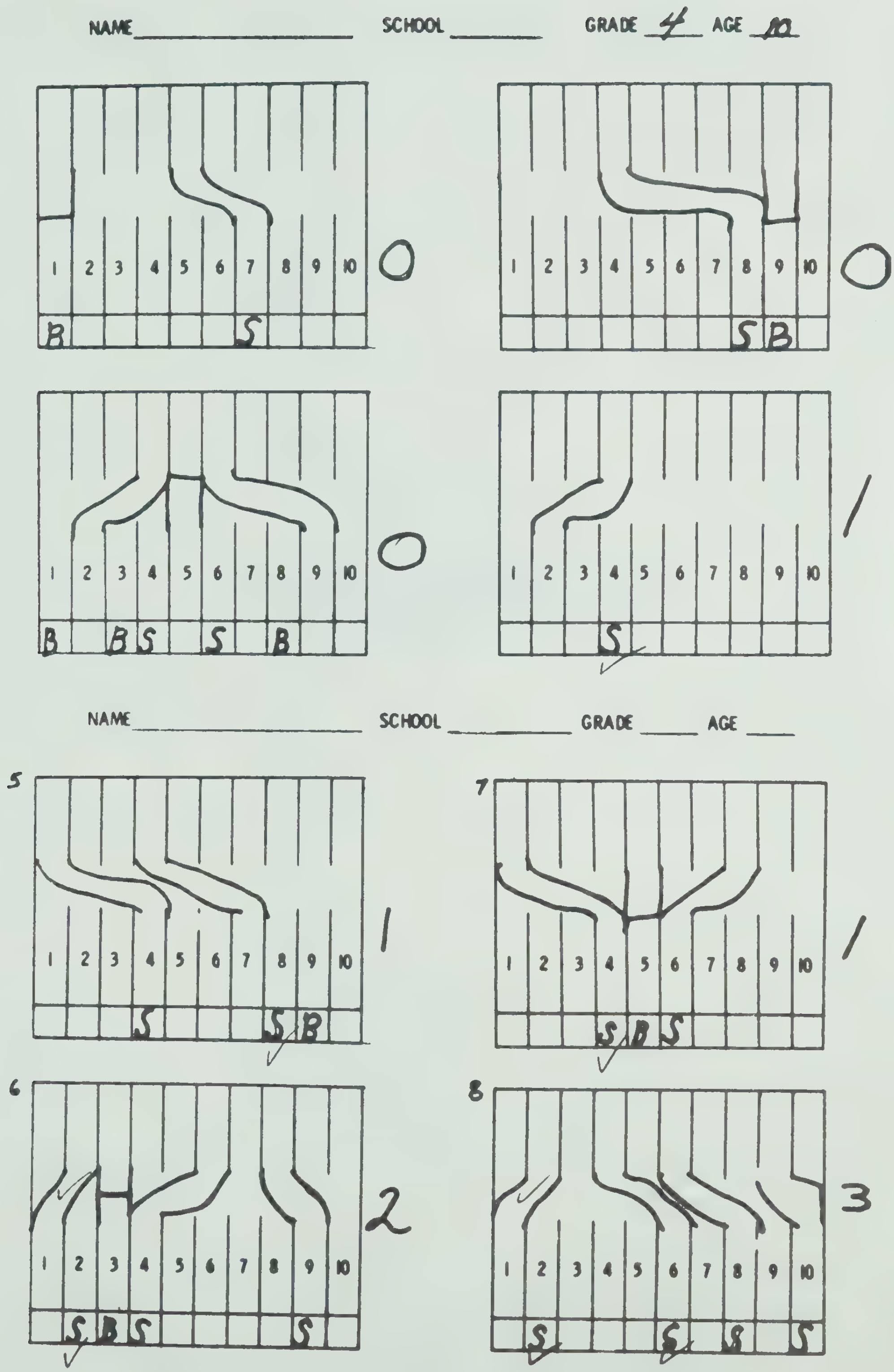
COMPLETED VISUAL INFERENCE TASK DATA
SHEET - HIGH SCORING STUDENT



(1/2 of natural size)

COMPLETED VISUAL INFERENCE TASK DATA
SHEET - AVERAGE SCORING STUDENT

8



(1/2 of natural size)

COMPLETED VISUAL INFERENCE TASK DATA
SHEET - LOW SCORING STUDENT

APPENDIX E

DATA SHEETS FOR AUDITORY-HAPTIC INFERENCE TASK

Project: P. Plester _ Inference 1972 Department of Elementary Education U of A

Name ______________ Grade ______ Age ____ School ____________

Room _______ Tape Number: Track _____ Side ____ Ft. _____

#1

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Ball, ball shaped, ball thing		
2. Way Object Moves	Rolls, Bounces, hops		
3. Weight	Heavy Medium Light		
4. Size	Small, little, like an orange, etc.		
5. Shape	Round, circle, oval, sphere, not square, fat, not a triangle		
6. Composition	Rubber, bouncy stuff		
Sound	Low pitch, dull, booming		
8. "Feel" as it strikes box	Vibrates, resilient, Soft		

#2

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Box, prism		
2. Way Object Moves	Slides Flips		
3. Weight	Heavy Medium Light		
4. Size	Book size, large		
5. Shape	Flat sides, box shape		
6. Composition	Cardboard, wooden		
7. Sound	Thumping, low tone, clunking, drumlike, banging		
8. "Feel" as it strikes box	Solid		

(2/3 of natural size)

AUDITORY-HAPTIC INFERENCE TASK DATA SHEETS

Category	1 Point	Score	Comment
#3			
1. Label	Cylinder, rod , rolleer		
2. Way Object Moves	Rolls Slides Flips, falls		
3. Weight	Heavy Medium Light		
4. Size	Pencil size, dimensions 6" x 1/2"		
5. Shape	Round with flat ends, rod like		
6. Composition	Steel, aluminum, metal		
7. Sound	High pitch, high sound, clanging sound, ringing sound		
8. "Feel" as it strikes box	Solid, hard, brittle		
#4			
1. Label	Disc,		
2 Vay Object Moves	Slides Rolls Flips		
3. Weight	Heavy Medium Light		
4. Size	Describe or compare -up to 1" thick -5"-& 7" in diameter		
5. Shape	Round and flat		
6. Composition	Soft material, plasticine,		
7. Sound	Thud,		
8. "Feel" as it strikes box	Solid, fairly hard		

Category	1 Point	Score	Comment
#5 1. Label	Pyramid		
2. Way Object Moves	Slides Tumbles		
3. Weight	Heavy Medium Light		
4. Size	Approx. 1/4 of box		
5. Shape	Square and triangular sides, five flat sides		
6. Composition	Hard material, plastic, hardwood		
7. Sound	Harsh, loud, brittle		
8. "Feel" as it strikes box	Solid, hard		
#6 1. Label	Mercury in balloon		
2. Way Object Moves	Tumbles Slides Flops		
3. Weight	Heavy		
4. Size	Size of orange, apple, baseball, tennis ball		
5. Shape	Amorphous		
6. Composition	Soft material, rubber like		
7. Sound	Thud, Slops,		
8. "Feel" as it strikes box	Vibrates Soft		

APPENDIX F

COMPLETED DATA SHEETS FOR AUDITORY-HAPTIC INFERENCE TASKS

Project: P. Plester _ Inference 1972 Department of Elementary Education U of A

Name ____________ Grade 6 Age 12 School ____________

Room 117 Tape Number: Track 1 Side 1 Ft. 091

#1

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Ball, ball shaped, ball thing	/	
2. Way Object Moves	Rolls, Bounces, hops	/ /	
3. Weight	Heavy Medium Light		
4. Size	Small, little, like an orange, etc.		Soft ball size
5. Shape	Round, circle, oval, sphere, not square, fat, not a triangle	/	
6. Composition	Rubber, bouncy stuff	/	
7. Sound	Low pitch, dull, booming	/	hollow sound
8. "Feel" as it strikes box	Vibrates, resilient, Soft		(sort of sticky)
		6	

#2

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Box, prism	/	smaller box or thick book
2. Way Object Moves	Slides Flips	/ /	falls
3. Weight	Heavy Medium Light	/	
4, Size	Book size, large	/	thick book
5. Shape	Flat sides, box shape	/	rectangle
6. Composition	Cardboard, wooden	/	cloth over something heavy
7. Sound	Thumping, low tone, clunking, drumlike, banging	/	like dropping a book ~~slap~~
8. "Feel" as it strikes box	Solid		
		8	

(2/3 of natural size)

AUDITORY-HAPTIC INFERENCE TASK DATA SHEETS - HIGH SCORING STUDENT

Category	1 Point	Score	Comment
#3			
1. Label	Cylinder, rod, rolleer		-toy car -wheels or bearings
2. Way Object Moves	Rolls Slides Flips, falls	/ / /	wheels on both sides
3. Weight	Heavy Medium Light	/	light
4. Size	Pencil size, dimensions 6" x 1/2"		
5. Shape	Round with flat ends, rod like		rectangular
6. Composition	Steel, aluminum, metal	/	
7. Sound	High pitch, high sound, clanging sound, ringing sound	/	rubbing sound -very little friction
8. "Feel" as it strikes box	Solid, hard, brittle	6	
#4			
1. Label	Disc,	/	land like a disc
2. Way Object Moves	Slides Rolls Flips	/ /	won't roll easily (turn over)
3. Weight	Heavy Medium Light	/	very light
4. Size	Describe or compare -up to 1" thick -5"-& 7" in diameter		
5. Shape	Round and flat		quite a few sides (thin)
6. Composition	Soft material, plasticine,	/	fabric over probably wood
7. Sound	Thud,	/	-lands heavily -almost a flat sound
8. "Feel" as it strikes box	Solid, fairly hard	6	

Category	1 Point	Score	Comment
#5 1. Label	Pyramid		something in front of it
2. Way Object Moves	Slides Tumbles	/	turn over
3. Weight	Heavy Medium Light	/	
4. Size	Approx. 1/4 of box		
5. Shape	Square and triangular sides, five flat sides		rectangular
6. Composition	Hard material, plastic, hardwood		metal
7. Sound	Harsh, loud, brittle		-very flat sound
8. "Feel" as it strikes box	Solid, hard		
		2	
#6 1. Label	Mercury in balloon		weighted inside
2. Way Object Moves	Tumbles Slides Flops	/	-could be filled with water falls, rolls
3. Weight	Heavy	/	
4. Size	Size of orange, apple, baseball, tennis ball		
5. Shape	Amorphous	/	-sort of like a bean -water in balloon bag
6. Composition	Soft material, rubber like	/	rubber of some sort
7. Sound	Thud, Slops,	/	-squeaky -watery sound
8. "Feel" as it strikes box	Vibrates Soft		lands very light
		5	-too strong to be a balloon
		33	

Project: P. Plester _ Inference 1972 Department of Elementary Education U of A

Name ______________ Grade 4 Age 9 School ______________

Room 3 Tape Number: Track 1 Side 1 Ft. 760

#1

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Ball, ball shaped, ball thing	1	
2. Way Object Moves	Rolls, Bounces, hops	1 1	
3. Weight	Heavy Medium Light		
4. Size	Small, little, like an orange, etc.		
5. Shape	Round, circle, oval, sphere, not square, fat, not a triangle	1	
6. Composition	Rubber, bouncy stuff	1	
7. Sound	Low pitch, dull, booming	1	Hollow sound -drum like
8. "Feel" as it strikes box	Vibrates, resilient, Soft		
		6	- has corners

#2

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Box, prism		-may be sand
2. Way Object Moves	Slides Flips	1	thuds
3. Weight	Heavy Medium Light	1	
4. Size	Book size, large		
5. Shape	Flat sides, box shape	1	-square like box
6. Composition	Cardboard, wooden	1	
7. Sound	Thumping, low tone, clunking, drumlike, banging	1	Thuds
8. "Feel" as it strikes box	Solid	5	

(2/3 of natural size)

AUDITORY-HAPTIC INFERENCE TASK DATA SHEETS - AVERAGE SCORING STUDENT

Category	1 Point	Score	Comment
#3			
1. Label	Cylinder, rod, rolleer		-magnet marble -steel boulder -has wheels
2. Way Object Moves	Rolls Slides Flips, falls	 / /	
3. Weight	Heavy Medium Light		
4. Size	Pencil size, dimensions 6" x 1/2"		
5. Shape	Round with flat ends, rod like	/	round like a ball
6. Composition	Steel, aluminum, metal	/	
7. Sound	High pitch, high sound, clanging sound, ringing sound		-clinging sound
8. "Feel" as it strikes box	Solid, hard, brittle	4	
#4			
1. Label	Disc,	/	-might be an ash tray
2. Way Object Moves	Slides Rolls Flips	/ /	-goes round and round
3. Weight	Heavy Medium Light		
4. Size	Describe or compare -up to 1" thick -5"-& 7" in diameter		
5. Shape	Round and flat	/	round and flat
6. Composition	Soft material, plasticine,	/	feels like rubber
7. Sound	Thud,	/	'circling' sound
8. "Feel" as it strikes box	Solid, fairly hard	5	

Category	1 Point	Score	Comment
#5 1. Label	Pyramid		
2. Way Object Moves	Slides Tumbles	/ /	- sort of jumping
3. Weight	Heavy Medium Light		
4. Size	Approx. 1/4 of box		
5. Shape	Square and triangular sides, five flat sides		must be square
6. Composition	Hard material, plastic, hardwood	/	maybe steel
7. Sound	Harsh, loud, brittle	/	real loud banging sound
8. "Feel" as it strikes box	Solid, hard		
		4	
#6 1. Label	Mercury in balloon		sand in
2. Way Object Moves	Tumbles Slides Flops	 / /	jumps
3. Weight	Heavy	/	
4. Size	Size of orange, apple, baseball, tennis ball		
5. Shape	Amorphous	/	shape of bean bag
6. Composition	Soft material, rubber like		
7. Sound	Thud, Slops,		- not very loud - bangs up and down
8. "Feel" as it strikes box	Vibrates Soft		
		4 28	

Project: P. Plester _ Inference 1972 Department of Elementary Education U of A

Name ______ Grade 2 Age 7 School ______

Room 4 Tape Number: Track 2 Side 1 Ft. 0

#1

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Ball, ball shaped, ball thing		
2. Way Object Moves	Rolls, Bounces, hops	/ /	-sort of slides - rolls
3. Weight	Heavy Medium Light		-kind of heavy
4. Size	Small, little, like an orange, etc.		
5. Shape	Round, circle, oval, sphere, not square, fat, not a triangle	/	
6. Composition	Rubber, bouncy stuff	/	-sort of plastic
7. Sound	Low pitch, dull, booming		-hard sound
8. "Feel" as it strikes box	Vibrates, resilient, Soft		
		4	

#2

CATEGORY	1 POINT	SCORE	COMMENT
1. Label	Box, prism		
2. Way Object Moves	Slides Flips	/	
3. Weight	Heavy Medium Light	/	-really heavy
4. Size	Book size, large		
5. Shape	Flat sides, box shape	/	-square
6. Composition	Cardboard, wooden	/	
7. Sound	Thumping, low tone, clunking, drumlike, banging		-loud sound (sort of)
8. "Feel" as it strikes box	Solid		
		4	

(2/3 of natural size)

AUDITORY-HAPTIC INFERENCE TASK DATA
SHEETS - LOW SCORING STUDENT

Category	1 Point	Score	Comment
#3 1. Label	Cylinder, rod , rolleer		
2. Way Object Moves	Rolls Slides Flips, falls	1	
3. Weight	Heavy Medium Light	1	- quite light
4. Size	Pencil size, dimensions 6" x 1/2"		
5. Shape	Round with flat ends, rod like		- roundish like a hammer
6. Composition	Steel, aluminum, metal		- probably made of wood
7. Sound	High pitch, high sound, clanging sound, ringing sound		- bit louder than last box
8. "Feel" as it strikes box	Solid, hard, brittle	2	
#4 1. Label	Disc,		
2. Way Object Moves	Slides Rolls Flips	1	
3. Weight	Heavy Medium Light		
4. Size	Describe or compare -up to 1" thick -5"-& 7" in diameter		-big like a big block
5. Shape	Round and flat		- probably a square shape
6. Composition	Soft material, plasticine,	1	-cardboard
7. Sound	Thud,	1	- plump sound.
8. "Feel" as it strikes box	Solid, fairly hard	3	

Category	1 Point	Score	Comment
#5 1. Label	Pyramid		
2. Way Object Moves	Slides Tumbles	1	
3. Weight	Heavy Medium Light	1	-quite heavy
4. Size	Approx. 1/4 of box		-big, like a real big ball
5. Shape	Square and triangular sides, five flat sides		-sort of feels round
6. Composition	Hard material, plastic, hardwood	1	- hard plastic
7. Sound	Harsh, loud, brittle	1	- big sort of plump
8. "Feel" as it strikes box	Solid, hard	~~4~~	
#6 1. Label	Mercury in balloon		
2. Way Object Moves	Tumbles Slides Flops	1	
3. Weight	Heavy	1	-quite heavy
4. Size	Size of orange, apple, baseball, tennis ball		
5. Shape	Amorphous		- square
6. Composition	Soft material, rubber like		- made out of steel
7. Sound	Thud, Slops,	1	-quiet sound
8. "Feel" as it strikes box	Vibrates Soft		
		3	
		20	

APPENDIX G

RANK ORDER OF CRITERIA SELECTED
BY EACH GRADE FOR THE
AUDITORY-HAPTIC TASK

RANK ORDER OF CRITERIA SELECTED BY EACH GRADE FOR THE AUDITORY-HAPTIC TASK

Grade Two	Grade Three	Grade Four
Movement	Weight	Composition
Composition	Composition	Sound
Sound	Sound	Movement
Shape	Feel	Shape
Weight	Shape	Feel
Label	Movement	Weight
Feel	Label	Label
Size	Size	Size

Grade Five	Grade Six
Sound	Weight
Weight	Sound
Composition	Size
Movement	Composition
Size	Shape
Shape	Movement
Label	Label
Feel	Feel

APPENDIX H

TRANSCRIPTION OF ONE STUDENT INTERVIEW FOR THE AUDITORY-HAPTIC INFERENCE TASK

TRANSCRIPTION OF ONE STUDENT INTERVIEW
FOR THE AUDITORY-HAPTIC INFERENCE TASK

Alright, what we are going to do this afternoon (if you want to stand up and come over to these boxes) we're going to do some work with those seven boxes that you see in front of you. You can see they are all the same color, all the same size and all the same shape. Ok now, each of those boxes has one object; one thing in it. Ok. Of course you can't see it because the boxes are all sealed shut. Now what I want you to do is to (we'll take one box at a time) pick it up, move it around, tip it this way, this way, upside down, shake it any way you want to, so you can learn as much as you can about the object in there. Then I want you to tell me as much about that object as you can. Anything you can tell me about it. Ok, now the first box there is empty, the very first one, so you can pick it up just to get an idea of what an empty box feels like. Feel how heavy it is. The rest of the boxes are made out of exactly the same thing, but they each have one object in them. Ok so you can put that one down and pick up number two and you can shake it and tip it. Tell me all you can about it.

S: Its kind of heavy

I: Its kind of heavy, (I'm going to be writing down everything you say). What else?

S: Its sort of bouncy

I: Its sort of bouncy. What else?

S: __________(10-12 seconds)

I: What kind of a sound does it make?

S: A hard sound

I: A hard sound?

S: Yeh

I: What shape do you think it is?

S: Round

I: Oh, you think it is round. And how does it move in there?

S: Its moving around when I move it

I: What is it doing when it moves; how is it moving? Is it sliding or tumbling or falling or what is it doing?

S: Its sliding

I: It slides in there does it? What do you think is in there?

S: A ball

I: Would a ball slide?

S: It could be rolling

I: Oh it rolls, I see. What else can you tell me? What is it made out of?

S: Sort of plastic

I: Sort of plastic. Anything else you can tell me about that ball or object or whatever you think is in there?

Ok, let's go to number three then.

I: What can you tell me about that one?

S: A big _______ ________, sort of heavy, really heavy.

I: Really heavy, eh. What were you going to say before that?

S: I think its square.

I: Think its square. Have you tried tipping it upside down? What else can you tell me about it? How does it move in there?

S: It slides

I: Slides, eh, and what?

I: Does anything else besides slide? Don't think so? What shape do you think it is? Oh, you said you think its square. What do you think its made of?

S: Cardboard

I: I think it might be made out of cardboard. And, what about the sound that it makes?

S: A loud sound

I: Loud sound! What else can you tell me about that one?

S: Anything? Ok, let's go to the next one then.

Number 4

S: Well ________________

I: Have you tried tipping it all different ways? Tip it right upside down

S: I think its made out of wood

I: Think its probably made out of wood? What else?

S: And, sort of roundish shape

I: Sort of roundish! Like ___________

S: half round

I: Oh, I see, like what? Do you know of something that would be shaped like that?

S: Sort of a hammer

I: Sort of a hammer! (6 seconds)

When you say roundish, you don't mean like an orange?

S: No

I: Ok, what else can you tell me?

S: Its quite light

I: Quite light eh? (4 seconds)

What do you think its made out of? Oh, you said wood probably. How does it move in there?

S: Well, it sort of slides

I: Just slides. Its sliding in there now is it?

And what about the sound that it makes?

S: A loud sound

I: Loud? You told me the last one was loud too. Was this just like the last one?

S: A bit louder

I: A bit louder. I see. (10 second pause)

Anything else you can tell me? (8 second pause)

Ok, lets to to number five.

S: Its probably a square shape

I: Its probably a square shape

S: Made out of cardboard. And its big

I: Big, How big?

S: Well, like a big block

I: Ok, what else can you tell me? (8 second pause)

How does it move in there?

S: Its moving.

I: What is it doing when it moves?

S: Its sort of sliding

I: Slides, eh? What do you think ______oh, you thought it was made out of cardboard. What about the sound that it makes?

S: Well _________ sort of makes a big sound like _________

I: Like what? How would you describe it?

S: Like a clump

I: A clump? (pause) Ok, anything else?
Ok, lets go on to number six, then

S: Its quite heavy

I: Quite heavy

S: I think its round

I: How do you - why do you think its round?

S: It sort of feels like it

I: Ok, what else can you tell me?

S: Its big

I: Big. How big is it? Big as an orange or a basketball or a grapefruit or ping pong ball or a marble or what?

S: Big as a real big ball

I: Ok, what else can you tell me? How does it move?

S: Just slides

I: Just slides, eh. What do you think its made of?

S: A hard plastic

I: A hard plastic. What about its sound?

S: A big sort of clump

I: A big sort of clump. Oh, anything else?

Ok, lets do number seven

I: What can you tell me about that one?

S: I think its made out of steel

I: Made out of steel. Why do you think its made out of steel?

S: Its quite heavy

I: Quite heavy (pause). So its heaviness that tells you its made out of steel. What else can you tell me about it?

S: Its square

I: Square. What makes you think its square?

S: _______________

I: It just is. What kind of sound does it make?

S: It makes a quiet sound

I: Quiet sound. And how does it move in there?

S: It slides

I: Slides, eh. (pause) What else can you tell me about it? (pause)

Anything? Ok, lets put that down and we can stop right there.

APPENDIX I

TIMING OF THE VARIOUS PHASES OF THE STUDY

Timing of the Various Phases of the Study

1. Pilot Study - 6.5 hours.
2. Main Study - 54 hours - Visual Task

   - 22 hours - Auditory-Haptic Task.
3. I.Q. Testing (Grades 1-3) - 8 hours (54 students in six schools).
4. I.Q. Testing (Grades 4-6) - 11.5 hours (54 students in six schools).

Total Data Collecting Time - 95.5 hours.